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SPECIAL ACCOUNTS

summing up the reports of the questions for discussion at the tenth session of the International Railway Congress Association (London, 1925).

SECTION I. — WAY AND WORKS. (1)

[625 .172 & 625 .173]

QUESTION I-A

(Maintenance of the track),

By R. RUFFIEUX, special reporter.

The object of the present report is to summarise the four reports prepared on the question of maintenance of the permanent way by :

Mr. W. H. Coomber (2) for the British Empire;

Mr. G. J. Ray (3) for America;

Mr. R. Ruffieux (4) for France; } (6)

Mr. H. Deyl (5) for other countries. }

As many facts and ideas are common to several of the reports, an analysis of the reports would involve considerable repetition; it is therefore rather by a process of synthesis, collecting the questions dealt with into a small number of groups, that we shall endeavour to give a general view of the whole.

The majority of the reporters point out that the space of time which has elapsed since the 1922 Congress has been too short to allow of adding much that is new to what was then said. It is therefore analytical detail rather than novelty of the ideas which characterises the reports submitted for your consideration.

Construction of permanent way.

On any given railway there are generally different types of permanent way, the earliest types only disappearing gra-

(1) Translated from the French.

(2) See *Bulletin of the International Railway Congress Association*, March 1925, p. 675.

(3) See *Bulletin of the International Railway Congress Association*, January, 1925, p. 1.

(4) See *Bulletin of the International Railway Congress Association*, March 1925, p. 699.

(5) See *Bulletin of the International Railway Congress Association*, May 1925 (2nd part), p. 1663.

(6) In the previous reports of Mr. Ruffieux and Mr. Deyl, the words « general overhaul » has in certain cases been translated as « relaying ». The latter in England usually implies the use of new material throughout, which is not the case in the « general overhauls » referred to.

dually. In Great Britain and France the standardisation of material has now been effected. Mr. Coomber considers that this is the principal achievement of recent years in the matter of the construction and maintenance of the permanent way.

Several of the reports mention the importance, as regards permanent way maintenance, of the development of the methods of draining and cleaning the formation, and the strengthening of the lines, the first essential of good maintenance being the satisfactory laying of the permanent way in the first instance.

Mr. Ray remarks that several railways, which have adopted a very heavy type of rail, weighing 130 lb. per yard, consider that an appreciable reduction in the general costs of permanent way maintenance is thereby attained.

Organisation of maintenance and inspection staff.

The most important modification noted by the reporters in the general organisation of railways is the fusion of British railways resulting in the formation of four large groups, which took place in January 1923. The standardisation which must necessarily ensue in the methods adopted by each of these groups is in process of realisation.

The Swiss Federal Railways, while not changing the basic principle of their organisation (*i. e.* the divisional system), have reduced the number of their divisions from five to three. The average length of line in a division has as a result increased from 576 to 962 km. (358 to 598 miles). The average length of line sections and districts has increased by about 20 %.

With the above exceptions, the reports do not mention any important changes in the organisation of the railway service or in the personnel engaged in inspection and maintenance of the permanent way.

Reference is made, however, to the increased size of sections (accompanied by a reduction of personnel), amounting in Great Britain to more than 8 miles on double lines and 15 miles on single lines; and in France, on secondary lines, to more than 15 km. (9 miles).

Similar steps have been taken by numerous railways in the United States and Canada, whereby it has been possible to reduce the increase of staff which would have been necessary as a result of the introduction of the eight-hour day.

Motor trolleys are used in America and France for the conveyance of men and materials on the sections of line. The British railways prefer to use ordinary trains which set down and pick up the men, morning and evening, at the place of work.

Permanent way inspection.

Mr. Coomber notes that the systematic daily rounds of inspection by section foremen have been recently reduced from 2 to 1 per day on almost all the British railways. In France one round per day is made on the majority of lines, while 2 rounds per day are made on double track lines or on the very busy lines of certain railways.

The report for France points out that these daily rounds account each year, on the large railways, for approximately 550 000 working days, part of which time could without doubt be more usefully employed.

General methods of maintenance.

The permanent way engineer, whose duty it is to organise the maintenance service, has the choice between two systems : 1° execution of work as found necessary; 2° a periodical general overhauling. Both systems have numerous partisans.

The first, after being in use for over a century, is still the only one in use on a large number of the railways of the

world, particularly in Great Britain, Denmark, Norway, Sweden and Switzerland.

In Great Britain the system is applied in the following manner. The necessity for executing small repairs is a matter for the decision of the section foreman, who, while conforming with the general regulations of the railway and with the instructions of his superiors, decides from day to day, during the course of his rounds, the nature of the work to be done and the order in which it is to be done.

Large repairs and general overhauling which are beyond the capacities of the repair gangs are decided upon by the inspectors or engineers.

The system of a periodical general overhauling was first adopted in France on the Alsatian Railways in 1865; it was applied to the whole of the Eastern Railway of France in 1877, and was afterwards adopted by other administrations; it was discussed at the Congress of Milan in 1887, and was recommended at the St. Petersburg Congress by Mr. Bruneel (1) and at Rome by Mr. Barbieri (2): at the present day it is adopted throughout the greater part of the Continent of Europe and America, and on the most important railways in the Latin colonies.

The system consists in the methodical and continuous execution once a year, by each gang, on a given section of line, of all the work necessary to remedy all defects and to put the line into as good a condition as possible having regard to its age and degree of wear. The system is applied from end to end of the principal lines, a portion of each section of line being dealt with each year until, after a certain number of years (which constitute the period within which the general overhauling has to be completed), each section has been put into as good a state of repair as its importance demands.

This period depends not only on the importance and nature of the line, the traffic, the climate, etc., but also on the economic situation of the railway. It is thus a complex question which it is not easy to determine.

An attempt is made to fix on the period most suitable to each section of line, taking into account both technical requirements and financial possibilities. Mr. Deyl remarks that as soon as it becomes urgently necessary to carry out numerous partial adjustments of the level and fittings of the line, it is a sign that the superstructure requires overhauling generally. These are the indications which in practice determine the period referred to above, though as a matter of fact the increase of traffic, the wear of material, financial considerations, or merely increased experience may lead to modifications of the scheme of work from one year to another.

In America the period is 3 or 4 years; in France from 2 to 8 years; in Belgium, 1 year for lines where there are more than 40 trains a day, and from 2 to 6 years for less busy lines; in Italy, 1 year on lines carrying a daily traffic of more than 15 000 tons, 2 years where the tonnage is between 3 000 and 15 000 tons, and 3 years for other lines; in Holland and Portugal, 2 years; in Germany, from 3 to 5 years.

During the time which elapses between two consecutive periods of general overhauling on a given section of line, maintenance is assured either by the regular execution of such day to day repairs as are found to be necessary during the daily rounds of inspection (America, Belgium, Spain, Italy, and certain French railways), or by a methodical overhauling once a year, though of a less detailed character than the main periodical overhauling (Northern and Paris-Lyons-Mediterranean Railways of France, Paris-Ceinture) and by partial overhauling confined to certain features

(1) See *Bulletin du Congrès des chemins de fer*, July 1892, p. 1905.

(2) See *Bulletin of the Railway Congress*, January 1922, p. 139.

such as the raising of joints, the tightening of the rail fastenings, the clearing away of grass, etc. This modified annual overhauling is stated by those administrations which adopt it to be an excellent system, especially for remedying defects which occur in the interval between two consecutive occasions of general overhauling. The general overhauling implies in practice the replacement of material which cannot be expected to last until the next general overhauling. In this connection Mr. Deyl points out that if too short an interval between two consecutive overhaulings leads to an excessive amount of general repairs, too long an interval on the other hand results in the premature replacement of material. This double difficulty may be avoided by carrying out a simplified form of annual overhauling, by which means it is possible each year to replace the material which has reached its limit of wear, and to extend the interval between two consecutive general overhaulings without running the risk of premature or overdue replacement of material; this does not, of course, prevent the execution of occasional repairs found to be necessary on the daily rounds of inspection.

The arguments generally advanced for or against the general overhauling system have been most ably set forth at previous congresses, particularly by Messrs. Bruneel and Barbieri. Mr. Deyl, without disguising the difficulties, or at any rate, in the early stages, the inconveniences resulting from the application of this system, summarises the advantages as follows : ready adaptation to financial restrictions, perfect system of control, more economic organisation, more efficient execution of work, correction of hidden defects and elimination of their causes, economy in the use of material and prolongation of its life, economical use of mechanical equipment, assurance that for a considerable period a line will remain in good condition from the point of view of the safety of traffic.

As regards the system of effecting repairs as found necessary from day to day, Mr. Deyl gives in a word the principal objection which can be brought against it : it is that under this system only obvious defects in the permanent way are repaired; and he points out that the Swiss Federal Railways, which adopt this system exclusively, only obtain satisfactory results provided the carrying out of permanent way repairs is done periodically, which amounts, in effect, to the same principle as the general overhauling system.

Mr. Deyl points out, however, that every railway administration has its reasons for considering its system the best suited to its own particular conditions, and in fact a comparison between lines maintained on the two systems does not furnish any decisive argument in favour of the one or the other. The condition of the British lines would seem to point to the conclusion that the system of maintenance by means of day to day repairs is the most perfect method possible, were it not for the fact that in other countries the condition of the permanent way would seem to justify a similar conclusion in respect of the other system.

As, therefore, the condition of the permanent way is no criterion, may it not be that the question is a purely economic one? Unfortunately, comparison between the financial situation of different railways is attended by such difficulties that we cannot hope to derive any conclusive argument therefrom. In the absence of any decisive word on the subject we will give the opinion of the reporters :

Mr. Coomber notes that the general overhauling system has not been adopted in Great Britain; in the case of the British colonies he refers, as being the most common, to a system under which the gangs cover their sections progressively

from one end to the other, carrying out as they proceed such repairs as may be necessary; in certain parts of India and in Malaysia a quarter of a mile of line is thus covered and repaired each day.

Mr. Ray states that in America the system of general overhauling, when the necessary labour is procurable on the spot, gives the most satisfactory results.

The reporter for France states that the general overhauling system is in use on all the large railways of France, Algeria and Tunis, and on the old lines of the Damascus-Hamah Railway.

Mr. Deyl, after having discussed the two systems, recommends a combination of the two, the regular overhauling being carried out during the most favourable periods of the year, the rest of the time being occupied in the repair of occasional defects revealed by the daily rounds of inspection.

Before passing to another subject we may be permitted to express a personal opinion, which is that there is no real antagonism between the two systems; neither one nor the other can be entirely dispensed with if the permanent way maintenance is to be completely satisfactory; the necessity for carrying out occasional repairs exists even though the system of general overhauling is adopted; in the same way, in the course of carrying out such occasional repairs, the opportunity is often taken to carry out the general overhauling of a certain length of line, though the overhauling thus carried out is neither continuous nor periodical. The two systems are based, therefore, on the same principles, whether the latter are applied systematically or as occasion demands.

Technical methods of working.

A. — Upkeep of material used on the permanent way.

The upkeep of the material used on the permanent way depends on numerous factors; we are only concerned here with the care to be given to it in the course of maintenance work.

a) *Rails.*

Mr. Coomber considers that the principal innovation of recent years is perhaps the yearly lubricating of fishing surfaces; this practice is also found on certain French railways.

The British and French reports state that the tarring of rails in tunnels and on lines near the seacoast has been found advantageous on certain railways. The provision of guard rails along the inside rails on sharp curves is the general practice on British railways, who consider this system effective in preventing derailing. In Algeria the outer rail is lubricated. Both practices have been tried in France.

In South Africa rails in which only the fishing surfaces have reached the limit of wear are cut and re-bored for further use on main lines. In Ireland use is made for this purpose of rapid rail-saws and drills. On certain British railways rails on curves which show excessive lateral wear are either turned, or exchanged with those of the opposite side, or exchanged with rails from straight lines.

Mr. Coomber also mentions that the South African railways use Sandberg steel for rails at sharp curves where traffic is heavy; it is stated that this prolongs the life of the outer rails by from 60 to 100 %, and of the inner rails by 25 %.

On the London District Railway, where the rails are particularly subject to uneven wear, the rails thus worn are taken up and the running surface is mechanically ground; they are then replaced and their life is thus doubled.

Further, Mr. Coomber states that the Canadian railways are experimenting with the repair of points and crossings *in situ* by the oxyacetylene process.

b) *Sleepers. — Timber sleepers.*

The method most generally adopted for prolonging the life of timber sleepers is to impregnate them with creosote before use. Mr. Coomber remarks, however, that in the British colonies this method is not generally adopted.

In order to extend the life of sleepers already in use, it is customary to re-adze the rail seats, to drill new holes after plugging the old ones, to change the position of the rail seats, to provide various wood or metal fittings and metallic ties to prevent the widening of the slots.

Metal sleepers.— Mr. Coomber records that a certain Indian railway has standardised the use of steel sleepers on a large part of its lines.

Metal sleepers are being increasingly used in France in the case of renewals; certain railways consider them not only as a resource in case of scarcity of timber sleepers, but as a means of reducing the cost of maintenance in the future. There is general agreement, however, in limiting their use to lines where the speed of trains does not exceed from 90 to 100 km. (56 to 62 miles) per hour.

Concrete sleepers. — The same considerations have lead in France to a more extensive trial of concrete sleepers. On certain trial sections the passage of several thousand trains has not produced the slightest effect either on the concrete or on the fittings. In view of the results already obtained there is every reason to believe that concrete sleepers will give long and excellent service.

As regards lines which carry only a small amount of traffic, the results which the Orleans Company has obtained on the line between Hautefort and Terrasson by laying concrete sleepers and blocks appear to be conclusive from the point of view of the rigidity of the track and of economy of labour and material.

Mr. Coomber remarks that one Indian railway has laid a considerable number of concrete sleepers for experimental purposes.

c) *Small fittings.*

According to the British report certain railways make use for repair work of special fish plates slightly higher than the ordinary fish plates, to compensate fo the wear of the fishing surface of the rails. In Ireland worn fish plates are levelled by a milling machine, and they are then re-used, U-shape keys being inserted between them and the rail.

In France worn fish plates are heated and re-shaped to give good contact with the fishing surface; they can thus be made to serve for a considerable further period on main lines.

In order to prevent the cutting of the foot of the Vignoles rail into the wood of the sleepers, the use of iron sole plates is very frequent on the railways of the British Dominions and Colonies, and particularly in Canada. In France, although a large number of them are still, in existence on the lines of the P. L. M., their use has been almost completely abandoned. The objection to them is that they accentuate the creep of the rails, and lead to the simultaneous wear of both rails and sole plates, to the extent of preventing the tightening of the coach-screws which run up against the upper surface of the sole plate before gripping the bottom flange of the rail. As a further objection it is stated that the noise caused by the passing of a train is much louder when these sole plates are in use. New rails are therefore generally laid directly on timber sleepers. Some engineers, however, place heeled sole plates under Vignoles rails which have a narrow base, as well as on sharp curves in order to increase the transverse resistance of the rail attachments by securing the coach screws.

In order to prevent the cutting of the metal into the sleepers, certain French railways make use of sole plates made of compressed poplar.

B. — Packing and levelling of tracks.

The methods of hand tamping and « shovel packing » in use on certain railways cannot be used indifferently the one for the other, this latter method being limited to effecting small increases in height on tracks which are already consolidated. This method, which is in general use in Belgium and on the majority of the large French railways, is only in the experimental stage on certain other railways. It is not referred to in the reports dealing with the English-speaking countries, though Mr. Chas. J. Brown stated at the Rome Congress that it was adopted on the London & North Western Railway. The railways which use it regularly attribute to it advantages which, in the opinion of Mr. Deyl, are sufficiently important to justify the use of timber or concrete sleepers in preference to metal trough-shaped sleepers, the latter not lending themselves to this system.

Tamping is generally done by hand. The reports for France and « other countries » contain details on this point, from which it appears that the methods adopted are far from uniform, and Mr. Deyl remarks that it would be desirable, both on technical and on economic grounds, to endeavour to ascertain which is the most efficient method.

Mechanical tamping is not very widely adopted. In the United States, however, certain lines which carry a heavy traffic are dealt with by this method. The American engineers consider that tamping done by this method is more rapid, even, and lasting. It is also less fatiguing for the workmen, whose energies are thus conserved for other work. The average number of sleepers tamped per man is double the number that can be done by hand in the same time. In Great Britain and France, at any rate so far as maintenance work proper is concerned, the mechanical method is only in the experimental stage. The experience so far gained in England has not been such as to justify the general adoption of this method. Two mechanical tampers are, however, in use on the North Eastern for special work. In France, the advantages of mechanical tamping are affirmed by certain railways and denied by others. The saving of time is estimated at from 20 to 25 %. The report for France states that the use of mechanical tampers appears to be less effective in the case of general overhauling than in the case of special operations necessary for the rapid consolidation of new material after relaying of the permanent way, or for maintaining at a constant level points which have a tendency to sink, on certain unstable stretches of line.

Trials have been carried out in other countries, and it appears that in Italy and Germany they have led to the adoption of mechanical tampers for the routine maintenance work of certain lines.

C. — Clearing away grass.

Most railways periodically clear their lines of grass, etc. Four methods are employed :

1° Mowing;

2° Pulling by hand;

3° Clearing by mechanical appliances;

4° Destruction by chemical or burning processes.

Mowing is but an imperfect remedy; it is generally done by hand; Mr. Ray notes, however, that in America a cheaper system is adopted, mowers being fixed to motor trolleys or to wagons.

Pulling by hand is slow and expensive, and requires a great amount of labour.

Mechanical appliances are used especially in Switzerland and on certain French railways; they are more rapid and cheaper than hand work, and very few employees are required for the work; but as the season during which the grass can be got rid of is comparatively short, the appliances used are,

from the economic point of view, unable to show a very high output. Against this, however, there is the fact that such appliances can be used at other seasons of the year for the dressing of ballast.

The French report refers to recent attempts to kill grass by spraying it with a liquid weed-killer, and it is stated that these experiments have been very successful. This method is simple, cheap, consumes very little water, and entails little labour. The experiments are being continued on a larger scale, and it appears likely that they will lead to a considerable extension of the use of this method.

Mr. Ray further notes the use in America, on long lines where vegetation is abundant, of machines which destroy the vegetation by the application of liquid weed-killers or superheated steam; but he considers that these methods are not economic on large, well ballasted lines, where it is preferable to pull up the grass by hand in the course of ordinary maintenance work.

D. — Cleaning the ballast.

All the reporters note the important place occupied by the cleaning of ballast in maintenance work.

The American report states that with a view to reducing the cost of screening, use is made of machines which screen the ballast and then replace it on the formation, the rubbish left by the screening remaining in the wagons which carry the apparatus. Ballast is laid either by means of a steam crane with grab-buckets, or by hand on travelling belts worked by the motor of the screening apparatus.

In France the present tendency is to clean the ballast at the time of the general overhauling; and in the case of railways on which this has been the practice for some considerable time it has been found that this avoids the necessity for screening or renewal of ballast on a large scale.

E. — Use of mechanical means.

The various reports, especially those prepared in the English language, mention numerous forms of apparatus, many of which are more especially designed for use in connection with the laying of new lines or renewals, rather than for routine maintenance work : motor trolleys, sleeper boring machines, tamping picks; apparatus for treating rails and sleepers, for opening out the lines, for screening ballast, for digging trenches; wagons for carrying and automatically unloading and laying ballast; drills, rail milling machines, adzes, steam or electro-magnetic overhead travellers, lifting jacks, etc.

Mr. Coomber notes in particular the favourable opinion held of the merits of the rail remover and layer and the rail « pick-up and scooter », and the advantages of Golightly rail-jacks, the use of which does not cause any obstruction of the permanent way while they are in action.

There is therefore no lack of mechanical equipment, but nevertheless, except in the cases to which we have referred above in connection with tamping and the lifting of rails by means of jacks, such mechanical equipment is not very widely used in Europe for ordinary maintenance work. The reports for the British Empire, France and the « other countries » agree in attributing this to economic reasons, the time when such apparatus can be employed being too short, and it being difficult to effect an organisation which gives perfect balance between manual labour and mechanical work.

Mr. Deyl has endeavoured to discover why, in spite of the advantages of mechanical tamping, the use of this system has not become general. In his opinion the reason is not only that tamping ma-

chines are still in process of evolution and are expensive, but that the economy which can be effected by their use has still to be ascertained. The same might be said of other mechanical appliances. Nevertheless, attempts to solve the problem continue, and in France experiments are being carried out in which the motive power of electrified lines and lighting current are being used to furnish the necessary energy for mechanical processes of maintenance work.

As regards America, Mr. Ray notes that the cost of maintenance has been considerably reduced by the use of a number of mechanical appliances. Numerous trials have been carried out, particularly for withdrawing or laying sleepers without having to disturb the rails; certain machines used for this purpose have resulted in a reduction of expense in the case of gravel or cinder ballast, but the experiments have not been particularly successful in the case of broken stone ballast.

Mr. Ray gives a description of the most interesting mechanical appliances in use. He devotes a special section of his report to motor trolleys, and emphasizes the necessity of scrupulously observing the regulations laid down to ensure their safe running. He also mentions tamping appliances which have 2, 4, 8 or 12 tamping rods, worked by electric motors or air compressors driven by petrol engines; machines for opening out the lines by means of which even lines with the heaviest stone ballast can be aligned and adjusted by three or four men, and many other tools, for a description of which we can only refer the reader to Mr. Ray's very interesting report.

Mr. Ray considers it necessary, in view of the development of mechanical processes of work, to have a special organisation for the repair of the mechanical equipment, and to provide instruction for employees in the proper use and care of such equipment. It has been found advisable in certain cases to detail a permanent way inspector to supervise the whole of the motor trolleys, tamping appliances, etc., of two or three sections, according to the quantity of the appliances in question. He has a number of fitters at his disposal to carry out necessary repairs on the spot and to overhaul the appliances completely in the workshops during the winter season.

Execution of maintenance work by railway personnel.

It appears from the reports as a whole that in principle maintenance work is undertaken by gangs of railway employees, assisted where necessary by temporary helpers, each gang working on a certain section of line several kilometres in length.

In the British Empire there are three kinds of gangs composed of regular railway employees :

Stationary gangs, who specialise in the maintenance work of a definite section of line;

Special mobile maintenance gangs who carry out repair work which is beyond the capacities of the local stationary gangs;

Relaying gangs.

On the majority of lines there are no special mobile maintenance gangs, and the more important repairs are carried out by the relaying gangs. On a certain number of railways these two classes of gangs are formed annually, either of temporary employees, or of regular railway employees who constitute a nucleus which can be reinforced as required by temporary helpers or by employees borrowed from local stationary gangs.

As a rule it is possible to carry out routine maintenance work without having to supplement the personnel of the stationary gangs, except in South Africa during the rainy season.

In America it is considered that it is cheaper to reinforce local gangs by tem-

porary helpers obtained locally, than to resort to the formation of special gangs.

In France, the work of the maintenance gangs may be divided into two categories :

1° Maintenance proper, comprising periodical methodical overhauling and isolated repairs;

2° Accessory and miscellaneous work, such as inspection, signal lighting, participation in relaying work or in the rearrangement or enlargement of stations, etc.

The time spent in accessory or miscellaneous work is often very considerable, and the addition of temporary helpers to the maintenance gangs is generally essential.

The number of men required for maintenance work is generally decided according to experience and local circumstances.

The British report states that few railways give precise information as to the fixing of the number of employees required for maintenance work. On one English line the scale adopted is one man for the lengths of line indicated in the following table :

2 400 yards of first class main line,

2 800 yards of second class main line,

3 300 yards of double track secondary line,

2 500 yards of single track secondary line.

In America a large number of railways determine the number of employees necessary on the basis of the coefficients suggested by Mr. Earl Stimson at the Rome Conference in his report on American railways. This method consists in adopting units for measuring work, by attributing to the various constituent elements of the maintenance work on a given section of line relative values in terms of units of length of single-track main line.

In France, the average number of employees per kilometre (per mile) of line is generally between 0.40 and 0.60 (0.64 to 0.96) on single line, between 0.84 and 1.33 (between 1.34 and 2.13) on double line, and between 1.0 and 2.56 (between 1.6 and 4.09) on lines which have four tracks.

The figures given in the report relating to « other countries » vary from 0.7 to 1.5 men per kilometre (from 1.12 to 2.40 men per mile) of single line. Certain railways adopt formulae of equivalence similar to those in use in America.

In most countries employees engaged in maintenance work are paid fixed wages, payable at stated intervals, and temporary men are paid by the day. As a rule neither piece work nor premiums on output are paid. In France, the amount of yearly bonus or allowances for length of service depends on the efficiency of the employee.

Execution of maintenance work by contract.

In his general report presented at the Rome Congress Mr. Earl Stimson stated that the question of the execution of maintenance work by contract was far from being solved, both the British and the American reporters being definitely opposed to the system, and the report dealing with « other countries » being definitely in its favour.

The situation is still much the same in the British Empire and America. In India and America, however, and particularly on the railways of South America, there are a few cases in which routine maintenance work is done by contract.

In France, as a result of the shortage of labour caused by the war and by the number of workmen required for reconstruction work in the devastated areas, it has become impossible in certain districts to obtain the temporary personnel necessary for reinforcing the maintenance gangs; consequently it has been found necessary to entrust the work to contractors, and contract work has been

much more general in the last few years in France than ever before.

The work let out on contract comprises either the periodical general overhauling of so many metres of line, covering a variety of clearly defined operations; or merely certain classes of work, particularly work which demands the greatest amount of time and labour, such as the relaying of sleepers, screening of ballast, etc.

Contracts for the execution of such work are placed after the receipt of tenders upon unit prices from contractors who specialize in permanent way maintenance work. The work is of course closely supervised by a railway official.

According to the report for « other countries », the administration of the Belgian State Railways considers that work on the superstructure may safely be entrusted to contractors; on the Italian State Railways the important periodical overhauling is done by contract, to the entire satisfaction of the railway administration.

From the information received by him, Mr. Deyl concludes that other railways do not employ outside contractors, though there is frequenty a kind of internal contract system under which certain classes of work which are easy to measure and to superintend are executed by railway employees themselves at fixed rates.

Finally, « farming out », as defined by the Milan Congress (1), that is to say, the execution by a single contractor of the whole of the maintenance work of a line at a fixed rate per kilometre, does not seem to be adopted in any country.

Comparison between maintenance work as done by railway employees and by contract respectively : Output, premiums, Piece work.

It appears from the various reports that from the technical point of view opinion generally is in favour of the execution of maintenance work by the railway personnel. This is natural, as the interest of these employees is in the efficiency of their work, whereas the primary interest of a contractor is the output of his employees. In practice the quality of the work done by contract depends to a very large degree on the efficiency of the workmen, and particularly of the gang foremen.

From the economic point of view, it was generally considered that the contract system was the more advantageous. This was in fact the experience of certain American railways; in France, however, it appears that the opposite has been the experience, and there is general agreement in considering that the contractor's profits and the cost of supervision render the contract system more expensive than the alternative system.

As regards other countries, Mr. Deyl considers that it is not possible to give a general answer to the question of the relative advantages of the two systems, though it is evident that only work of a certain importance can be done economically on the contract system.

If the saving of expense is problematical, the saving of time is beyond doubt in the case of employment of the contract system, the output of a contractor's men, working on a piece work basis, being generally higher than that of railway workmen.

Accordingly, consideration is being given to the possibility of increasing output, when the work is done by railway employees, this being the only point in which this system is inferior to the contract system.

A detailed study of the question of output must be based on an analysis of the more complicated forms of maintenance work, and a determination of the time necessary for the execution of the more elementary work. Such a study is therefore bound up with the question of methods of work.

Mr. Deyl devotes the greater part of

(1) See *Bulletin du Congrès des chemins de fer*, November 1887, p. 1391.

the third chapter of his report to this important question. He shows that the essential conditions of economy in maintenance work are : the execution of the work according to a programme, the preparation of a budget of expenditure, the methods of work, and the efficient supervision of the work. He repeatedly emphasizes the necessity of a careful study of the organisation of the different sections of maintenance work, of the analysis of the elementary work, and of the adoption of the best technical and economic methods for the execution of such work; but, while considering that certain forms of workshop organisation could undoubtedly be applied to permanent way construction and maintenance work, he states that the information supplied to him does not enable him to determine in what measure such an application would be feasible, and what results might be expected therefrom. He considers, however, that detailed statistics with regard to the elementary or complicated operations of maintenance work are essential for the compiling of estimates and the control of output, and are of great value from the point of view of economy.

According to the British report, the majority of railways do not attach any great value to statistics and to analysis of elementary forms of maintenance work and their net costs; such data are only prepared in respect of certain items such as material, labour, etc.

According to the French report, most railway companies are agreed in considering that the « taylorisation » of maintenance work has the disadvantage of dispersing the employees in a large number of small gangs engaged in a diversity of work; this system does not lend itself readily to analysis of maintenance work into elementary operations, with a definite timetable in which each operation is the same, whatever the place and time of its execution. Certain railways, however, have endeavoured to determine the time necessary for these various operations, and to solve the question of output bonuses and piece work. The only means of improving output without impairing the quality of the work, when done by railway employees, is in fact to give the employees a personal interest in the work, either by the granting of bonuses or by paying them by the piece.

Neither of these systems is employed in the British Empire or in France. As regards America, Mr. Ray recalls the bonus system described by Mr. Earl Stimson in his report of October 1921, presented at the Rome Congress.

According to the report dealing with « other countries », some administrations grant output bonuses for certain classes of work. For example, the Belgian State Railways pay higher wages for work which has to be done hurriedly; the Dutch State Railways grant special remuneration for increased output; the Italian State Railways, which granted bonuses before the war and subsequently abandoned the system, intends to reintroduce it; the Swiss Federal Railways have tried the bonus system.

The difficulties inseparable from the application of this system are the same difficulties as are met with in the « taylorisation » system, and do not as yet appear to have been completely solved.

With a view to improving output it might be desirable to try allotting a daily task to employees, though retaining the fixed wage. The difficulty in this system would be the accurate computation of the actual work involved in the tasks allotted; the normal timetable periods of work, in the case of elementary work, are not determinate except as averages worked out over a large number of cases; their application to individual tasks might often be inequitable. It is possible to allow for the unequal quantity of work involved in the various tasks when employees are actually paid on a piece work basis, as is the case in work done by contract, because in the long run the average works out equitable for each employee, and because it is in their

interests to carry out each task allotted to them in the least possible time; but it is obviously a different matter if wages are independent of the work done.

Finally, several reports refer to one method of improving output, which consists in the instruction and training of the personnel. Certain railways, according to the reports for Great Britain, France and « other countries », have instituted instruction centres for this purpose, with special courses or lectures.

Supervision of maintenance work.

The supervision of maintenance work is effected by the foremen during their rounds, and periodical reports are prepared which make it possible for the administration to follow the progress of the work.

The French report emphasizes the importance, as regards control, of the frequency of the rounds of inspection; many administrations in various countries place line trolleys at the disposal of the inspection staff to facilitate their work.

The British and French reports note the use of the *Hallade* apparatus for registering the oscillations of a running vehicle, and thus, other things being equal, ascertaining the condition of the line.

Finally, for verifying the gauge and the tilt of rails, various types of apparatus are in use based on the principles of the *Dorpmüller* apparatus, which is in use particularly in France and Switzerland.

Renewal of permanent way material.

We shall only refer to renewals of the whole of the material on a main line, without interruption of traffic on such line, partial renewals, or renewals carried out during a suspension of traffic, being of less interest.

The methods adopted are of two kinds:

Under the first method all the component parts of a certain length of line are relaid between the passing of two consecutive trains, the length of line thus treated depending on the space of time available.

Under the second method the line is relaid in parts, for example by changing first of all the sleepers and then the rails, or inversely.

The first method may be applied in one of two ways.

The simpler way is to take up the material of the old track piece by piece, after having detached it, and then to lay successively the sleepers and rails of the new track, they having been previously prepared to fit the position they are to occupy. This is the procedure most generally adopted, especially on the British, French, Belgian, Italian, Swiss and Spanish railways.

The second way is to assemble the new track by the side of the old one, and to effect the substitution by sliding the new track into position as soon as the old ones have been taken up.

The successive renewal of different parts of the track may also be effected either by replacing sleepers and rails one by one, or by inserting successive sections which have been fitted together in advance.

Mr. Deyl gives some very interesting examples of these various methods.

It is evident that choice between the different methods must depend on local conditions and on the object in view. In any case, the work may be carried out either by the railway itself or by contract.

In the British Empire renewals are carried out by the railway itself, generally by gangs of specialist workmen, except in certain cases in India, where the work is done by contract. On certain railways these specialized gangs are reinforced by temporary employees, particularly in the British Dominions. In Scotland platelayers are detailed either

to form a new gang, or to reinforce a small permanent gang.

In the United States the work is generally done by the railway itself, whereas in South America it is frequently done by contract. In France, Belgium, Italy and Switzerland renewals are generally carried out by contract, and in other countries by the railway staffs.

The preference shewn by the majority of railways for the system of entrusting renewal work to the railway personnel is due to the confidence which this system inspires from the point of view of the quality of the work and of safety; but administrations which have adopted the contract system have not had reason to complain, and indeed such administrations, from the economic point of view, generally prefer this system to the other for this class of work.

It is chiefly in the United States and Great Britain that mechanical relaying apparatus has passed into general use.

In the United States the distribution of new rails and the placing in position of the rails distributed are generally done by means of movable cranes worked by steam or compressed air and carried on material trains. For laying rails certain railways make use of hand cranes, which can be worked by from 5 to 7 men. Mr. Ray also notes the use, for laying rails on long stretches of line, of engine-cranes, which are capable of serving a detachment of 200 men engaged in unfastening and lifting old rails, and bolting and spiking new rails as they are placed in position by the crane. The use of this crane is considered to be economical in the case of lines on which the train service can be suspended.

In Ireland one railway has recently used a special train, made up of 40-ton bogie wagons on which an electric crane can run from one end to the other on a trolley. With this crane it is possible to take up or lay complete lengths of line. The new line is assembled at the depot in sections, which are loaded on to the train by means of an electric overhead travelling crane, and then carried to the spot and placed in position by the special train; the old line is also taken up, carried to the depot, and unloaded in complete sections before being dismantled.

The British report also notes the use of wagons specially constructed for loading and unloading rails.

In France and the other countries the use of mechanical equipment in relaying work is generally limited to sleeper boring or ballast tamping appliances; the use of these appliances is, however, not very general, and where used at all (at any rate in France) it is generally in the case of contract work, where they result in a certain reduction in the cost of labour. On the Northern Railway of France, however, the trains specially formed for carrying permanent way material comprise wagons equipped for the mechanical loading and unloading of rails.

Relaying of ballast.

The same question arises in the case of the renewal of ballast as in the case of the relaying of rails, *viz.*, whether the work is to be performed by the railway personnel or by contract, and whether mechanical equipment is to be used or not.

In America and France it is the practice to re-use part or all of the old ballast when it is possible without inconvenience to raise the track on a lower layer of new ballast.

The British report notes that the brake van of the special trains used for the mechanical unloading of ballast is generally fitted with a plough for levelling the surface of the ballast which has been unloaded. Mr. Coomber also mentions the Lidgerwood apparatus in use in Canada, which unloads the ballast of a whole train by means of a sort of distributing plough which is drawn from one end of the train to the other over the

floor of the wagons by means of a winch fixed on the truck immediately behind the engine. A similar system is in use in New Zealand.

In the United States use is made of special automatic unloading wagons for spreading ballast.

The French report does not refer to any new departure in the methods of relaying ballast.

Mr. Deyl gives a description of the methods in use on the Italian and Belgian State Railways. The difference between the two methods is that in the first case the track is completely lowered on to the formation, the old ballast being entirely removed before the new is put in; whereas in the second case the track remains at its normal level, the old ballast being left under each sleeper until the rest of the track has been filled with the new ballast; the old ballast remaining under the sleepers is then taken out with the aid of picks, the rails being supported meantime by jacks, after which the new ballast is filled in and rammed.

Mr. Deyl points out the technical advantages and disadvantages of these two systems.

Simultaneous relaying of rails and ballast.

The relaying of rails and ballast is not generally done simultaneously, for the life of the two is not the same. Several reports, however, remark that it is bad policy to lay a new track on poor ballast. Mr. Deyl is of the opinion, therefore, that the most rational system is the complete and simultaneous renewal of the whole superstructure, it being of course understood that the old ballast can be re-used after it has been cleaned.

In France the present tendency is to clean the existing ballast whenever rails or sleepers are renewed; it is unnecessary to add that if the ballast cannot be cleaned and re-used, and if at the same time the rails and sleepers have reached their limit of wear, the whole superstructure is renewed at the same time.

SUMMARY.

Before setting out the final summary, it is usual to review briefly the most important general considerations contained in the special report; in order to conform to this custom we will once more call attention to the following points :

In the general organisation of railways we note first of all a tendency towards unification, manifest particularly in the re-grouping of the British railways, in the standardisation of material in Great Britain and France, and in the reducing of the number of men in a gang by eliminating those who are superfluous.

An attempt is also being made, either on the basis of empirical formulae (America) or on the results of actual experience, to fit the number of employees as closely as possible to the actual work to be performed; and, further, in the interests of maintenance work, administrations endeavour to reduce the time spent in permanent way inspection.

It is clear from the reports taken as a whole that a normal system of maintenance can only attain its object if it is applied to a normally constructed line. It is therefore essential to improve formations if they are defective, and to reinforce or replace lines if they are too weak. It is only when these operations have been effected (a question of construction rather than of maintenance) that the maintenance service can carry out its duties under satisfactory technical and economic conditions.

The two systems of maintenance (*i. e.*, the execution of isolated repairs, etc., where necessary, and periodical general overhauling) have both been found satisfactory by the companies which have adopted them. The latter system is apparently becoming more and more favoured, and appears to be in existence

on the majority of railways in America and on the Continent of Europe. In the intervals between periods of general overhauling, the system of carrying out isolated repair work as and where necessary is adopted by most railways; some railways, however, prefer to carry out a reduced scheme of annual overhauling, though always methodical and continuous.

Technical methods of working do not appear to have changed appreciably since the date of the Rome Congress. The British and French reports deal at length with the question of the care to be devoted to material in use, with a view to prolonging its life; they mention in particular the lubrication of metallic surfaces which are liable to rapid wear by friction, and to various methods of prolonging the life of fish plates. The most important innovation appears to be the system adopted in Canada of carrying out certain repairs on the spot by oxyacetylene treatment.

« Shovel packing », alhough it cannot be substituted for tamping in all cases, is considered an economic process by those who use it. The process has developped since 1922, and is in regular use in Belgium and France. It is being experimented with on other railways.

Tamping by hand, although an old method, has not yet been perfected, since it is still carried out in a great variety of ways. Mr. Deyl notes this fact, and emphasizes the necessity, in this as in other cases, of endeavouring to ascertain the method which is the best from the technical and economic points of view.

From these two points of view the best method of tamping, in the opinion of the American experts, is the mechanical method; the superiority of this method is not contested by the other reporters.

There is a marked increase in the use of mechanical, chemical or « burning » processes for clearing lines of the growth of vegetation.

The reporters are unanimous as to the necessity for the periodical treatment of ballast, which is indeed carried out, when necessary, in the ordinary course of general overhauling.

Finally, we must call attention to the great development of mechanical processes in maintenance work in the United States, where such processes have been found advantageous both technically and economically. Europe is much less advanced in this direction, the obstacles encountered being largely of an economic nature. In Italy, however, the smaller forms of mechanical equipment appear to be in general use, and other countries are considering the possibility of adopting mechanical processes, especially in the case of electrified lines.

On most railways motor trolleys are being increasingly used for carrying men and materials. They make it possible to deal with longer stretches of line with a reduced personnel.

As a rule, maintenance work proper is carried out by the railways themselves, by means of working gangs assisted, where necessary, by temporary helpers.

Some administrations, however, particularly in non-English speaking countries, let out the work on contract, especially in the case of the more important branches of the work. The technical results obtained vary according to the nature of the work and the efficiency of the contractors' staffs (much depends on the efficiency of the foremen). From the economic point of view it is evident that in general maintenance work, if done by contract, is more expensive than if it is undertaken by the railways themselves.

Efforts are made to improve the output of the railway maintenance personnel, if not by the introduction of piece work (which is difficult in view of the fixed wages of permanent employees and the varied nature of the work), at all events by the granting of output bonuses. The application of the latter system is under consideration or on trial

in various countries, but the difficulties encountered in this direction have not yet permitted of its generalisation.

With the same object, *i. e.*, to improve output, attempts are being made to define the elementary and complex forms of maintenance work, and to determine, in the case of each class, what are the best working methods to be adopted, and what is the normal time required for the execution of each operation.

The quality and quantity of maintenance work is controlled by rounds of inspection (for the making of which attempts are being made to provide increased facilities), by periodical reports or diagrams, and by the use of special apparatus for recording mechanically the condition of the line surface.

The relaying of rails and ballast is generally undertaken by the railways themselves in English-speaking countries, whereas in other countries it is usually done by contract.

The method usually adopted is to relay completely a certain section of line between the passing of two consecutive trains.

For renewals on a large scale use is made in certain cases in Great Britain (and habitually in the United States) of various kinds of mechanical equipment for speeding up the work and reducing costs. Mechanical dowelling and tamping have been found useful in permanent way maintenance work.

For the renewal of ballast, tip wagons or hopper wagons are in use in certain countries.

The simultaneous renewal of both rails and ballast becomes necessary when both reach their limit of wear at the same time; even when this is not the case, it is desirable that new rails should be laid only on good ballast, and this is arranged by cleaning the ballast before the rails are changed, or during the relaying.

Finally, as the cost of labour is the most important consideration in maintenance budgets, an effort is made in all countries to reduce the number of employees engaged in maintenance work and to improve their output, whether by improving the organisation and methods of work, or by substituting mechanical processes for manual labour.

FINAL SUMMARY.

The above facts have lead the reporters to draw up the following summary :

1° The proper construction of the formation and superstructure is a *sine qua non* of efficient maintenance work;

2° The standardisation of material is desirable for both technical and economic reasons;

3° It is desirable to reduce as far as possible the time spent in systematic daily rounds of inspection;

4° It is desirable, either on the knowledge gained by past experience, or by adopting some method of suitable distributing the various elements of maintenance work, to determine exactly the proportion which should exist between labour employed and work done;

5° Although the system of carrying out local maintenance work where found necessary is adopted on many railways, the majority of the reporters consider that the system of a periodical general overhauling is the safer and more economical. The two systems are perhaps not so different from one another as might be supposed, both being based on the same principles, although in one case these principles are applied according to the necessities of the moment, while in the other they receive a more systematic application. In any case, both systems give excellent results in the hands of companies who know how to work them;

6° The technical processes adopted in the different branches of maintenance work are not uniform. It would be

useful if systematic experimental work could be undertaken with a view to determining the best methods of work applicable to each operation, taking into account the advantages to be derived from the use of mechanical appliances;

7° It is essential, for economic reasons, to prolong as far as possible the life of the material used in the permanent way, and in particular not to scrap sleepers before they have reached their limit of wear;

8° The obstacles encountered in Europe as regards the development of mechanical processes in routine maintenance work are generally of an economic nature : high cost of the mechanical equipment, inadequate daily output of the equipment resulting from the difficulty of co-ordinating mechanical work and manual labour on a given piece of work. These obstacles, however, are not met with in America, where considerable economies are effected by the use of not only small appliances such as tamping machines, but also of much more powerful machines, such as machines for screening ballast, levelling the track, etc.;

9° Motor trolleys (provided due regard is paid to the regulations relating to the safety of running on the line) constitute an economic means of transporting men and materials;

10° The grouping of maintenance personnel into gangs for work on long stretches of line, and the provision of rapid means of transporting the gangs (trains or trolleys), generally gives satisfactory results;

11° The ordinary routine forms of maintenance work do not lend themselves to the contract system, and should be carried out by the permanent personnel of the railway, augmented where necessary by temporary employees.

For the more important work, the same system is still to be preferred, but there is no real objection (and indeed in certain cases it may be desirable, either for economic reasons or because of the scarcity of labour) to having the work performed by contract, provided contracts are placed on the results of competitive tendering;

12° As the formen's rounds of inspection are essential for the efficient control of maintenance work, they should be not only increased, but facilitated by the provision of adequate means for the rapid transport of such employees during the execution of their duties.

Recording apparatus of the *Hallade* type constitutes a valuable auxiliary means of controlling maintenance work;

13° The analysis of the various operations comprised in maintenance work, and the rational application of such analysis to the organisation of the work, is a problem which calls for considerable further study. This question is intimately connected with the further question of the control of output, of bonuses and of piece work. It does not appear that the investigations so far carried out in this direction have resulted in any general solution of the problem;

14° The use of powerful mechanical appliances, such as those in use in certain parts of the British Empire and in America, may be expected to transform the technical aspect of the problem of renewals of the superstructure of the permanent way.

As regards the older processes, in which mechanical appliances play but a small part, it is desirable to determine by systematic research which are the best methods from the economic and technical points of view.

This class of work may be carried out either by the railways themselves or by contract, with equally satisfactory results; choice between the two systems is determined by the circumstances of each particular case, or by the conditions peculiar to the individual railway.

QUESTION I-B

(Level crossings [Public roads]) (1),

By R. RUFFIEUX, special reporter.

The question of dispensing with gate keeping at level crossings, raised for the first time at the Rome Congress, has been included in the agenda for the London Congress, where it is to be the subject of four reports :

No. 1, Mr. Maas-Geesteranus, for all countries except those included in the following reports, and the British Empire (2) ;

No. 2, by Mr. R. Ruffieux, for France (3) ;

No. 3, by Mr. G. J. Ray, for America (4) ;

No. 4, by Mr. D. Mendizabal for Italy, Spain and Portugal (5).

The British Empire is not included in any one of the reports except Canada, which is dealt with in the American report.

The object of the present report is to form a summary of the four reports mentioned above.

Legal and administrative regulations relating to level crossings.

Each of these reports contains particulars concerning the legal and working arrangements that regulate the control of level crossings, and gives the advantages and difficulties encountered in endeavouring to do away with gate keeping in the various countries. For instance, in Holland it was found that in order to make this change in the main lines, it was necessary to alter the law on the subject. In Belgium and Sweden, no legal restrictions had to be faced, whilst in Denmark, Spain and Portugal, it has not been found possible to abolish the present method of gate keeping. In the Republic of Czecho-Slovakia, the present laws would have to be altered as regards lines on which the speed is greater than 25 miles per hour. The abolition in France has attached to it conditions which have prevented progress being made. In Italy, a decree passed on 7 November 1920 gave the State Railways very great latitude as regards dispensing with crossing keepers, subject only to certain technical conditions.

A very elastic organisation in the United States generally allows the State or Municipal Commissions to decide, within the limits of the law, all questions relative to the construction and use of level crossings.

The abolition of gate keeping at level crossings has developed in each country according to the legal requirements or

(1) Translated from the French.

(2) See *Bulletin of the International Railway Congress Association*, number for February 1925, p. 203.

(3) See *Bulletin of the International Railway Congress Association*, number for March 1925, p. 761.

(4) See *Bulletin of the International Railway Congress Association*, number for January 1925, p. 13.

(5) See *Bulletin of the International Railway Congress Association*, number for May 1925 (2nd part.) p. 1621.

regulations in force, and for this reason, on the Italian State Railways, nearly 6 000 out of a total of about 13 000 level crossings now have no gate keepers; in Holland, more than 1 000 out of nearly 3 000; but scarcely 700 out of 30 000 on the great French lines.

Level crossings which have never had gate keepers.

It has generally been the case that regulations issued at the start as regards level crossings have remained. It had been foreseen, however, that when a line was being constructed, certain crossings with small traffic might be left without attendants, but no doubt it was never thought that a day would come when it would be considered advisable to abolish existing barriers, and this is the reason why in most countries the level crossings which were free from the beginning are more numerous than those where gate keeping has been done away with. In Denmark, for instance, unattended level crossings on lines that are not fenced-in represent 26 % of the total number. Most of the level crossings on secondary lines in France are free, and about 2 500, say 8 %, on the main lines were constructed without barriers from the start. This proportion amounts to more than 50 % in Czecho-Slovakia, about 27 % in Spain, and 50 % on the Portuguese Railways. Many of the level crossings situated in thinly populated districts in the Argentine Republic have neither barriers nor gate keepers, and on the Buenos Ayres Great Southern Railway only 336 crossings out of 2 214 are provided with barriers and keepers.

Abolition of gate keeping.

The absence of keepers at level crossings is therefore no novelty. What is new is the tendency on important lines to make it a general rule, when before it was an exception.

This tendency is justified not only by the economical necessities resulting from the great war, but also by the evolution of road traffic. As regards this, Mr. Ray points out that the old regulations applied to road traffic which was comparatively slow and crossed lines over which fast trains ran. To-day, when automobiles vie with trains in speed, precautions which formerly were thought to be sufficient are no longer so. Barriers which effectively protected the tracks are often knocked down by motor vehicles, and it is not a rare occurrence for the latter to run into a train when passing a level crossing. For this reason, in the United States, where there are no less than 256 000 of these crossings on 1st class lines, and 15 millions of motor vehicles on the road, it is generally acknowledged to-day — not-only by the high railway officials, but also by the public authorities — that a good automatic system of warning signals, acting day and night, give much greater security — except perhaps where the traffic is very dense, or in the streets of towns — than the protection that could be given during a part of the day by gate keepers or watchmen. Many clear thinking minds therefore consider that it would be an improvement to make the users of the road responsible for the safety at level crossings, rather than an attendant. When this idea has entered into the public mind, an immense forward step will have been taken, and the question of dispensing with gate keeping at level crossings will have been solved.

Mr. Ray points out that the American Railway Association has made long and numerous efforts with the object of continually reminding users of the roads of the precautions they should take on approaching level crossings.

It is impossible to praise too highly

the initiative in making public the progress that would result to the general interest by abolishing gate keeping. Such action induces the public authorities to help in the matter and the idea to be accepted by public opinion.

Conditions permitting dispensing with keepers at level crossings.

A. — General conditions relating to safety.

The conditions appertaining to the safety of unattended level crossings may be simply stated as follows :

1° Drivers of vehicles approaching a level crossing should be able to be aware of the fact in time to stop before reaching it;

2° It is then necessary to make certain that no train will come along while crossing the lines.

We shall now examine, from the reports sent in for the Congress, how these conditions are realised in the different countries.

B. — Frequency in running of traffic.

Generally speaking, the conditions relating to frequency in running the traffic refer chiefly to that on roads rather than on the lines, the former of which should — without any precise definition — be on the small side. In France, however, the number of trains must be less than three per hour; in Argentine four per day, and not exceeding the speeds allowed. In Switzerland, gate keeping is dispensed with only on main or secondary lines where the traffic is of average or small importance.

In general the rules, as far as the line is concerned, apply to the speed rather than to the number of trains, because the time during which trains approaching level crossings are visible is a function of this speed.

As an exception to the general rules relating to small traffic on the roads, Austria, Italy, Sweden and the United States admit that under certain conditions of visibility, or with an efficient system of warning signals, gate keeping at level crossings may be dispensed with, even on roads where the traffic is large.

C. — Conditions of visibility.

a) *Field of view.*

The field of view depends on the speed of trains and the class of traffic running on the roads, so it is quite natural that the fastest trains and the slowest road traffic should be the first consideration.

The abolition of the supervision at level crossings in Belgium in cases where the road traffic is of small importance and the view of the railway track from the road at a distance of 10 feet from the outside rail amounts to :

1 640 feet on lines run over at 62 miles per hour;

1 000 feet on lines run over at 37 miles per hour;

660 feet on lines run over at 25 miles per hour;

which corresponds to a minimum duration of visibility of about 18 seconds.

A Royal Decree recently promulgated by the Swedish Government provides that the safety regulations now in force (bells, luminous signals, barriers), are not generally necessary at crossings on lines when the speed of trains does not exceed 16 miles an hour, or when from a point on the road situated at 165 feet from the line it is possible to see oncoming trains at a distance from the level crossing amounting to :

445 feet when the maximum speed on the line is more than 16 miles per hour, but does not exceed 25 miles,

660 feet for speeds of 25 to 37 miles per hour,

985 feet for speeds above 37 miles per hour.

These three figures correspond to a minimum duration of visibility of about 12 seconds.

The level crossings on secondary lines in Holland (that is to day, those on which the speed does not exceed 37 miles per hour), are not usually under supervision, if from a point situated in the middle of the road and about 30 feet from the track, the approach of trains can be seen when they are at a distance of 820 feet from the level crossing. The Minister may also sanction the abolition of gate keeping on main lines in cases where he considers there is sufficient visibility.

In Austria it is thought that the danger zone at a level crossing extends up to 6 1/2 feet from the outside rail, and the principle has been adopted that users of level crossings when 6 1/2, 13 or 20 feet from the danger zone, according to the importance of the line, should see the approach of trains at such a distance from the level crossing that they may be able to pass over it before the trains running at the maximum speed allowed on the line can reach the crossing.

The Association of German Railways has adopted a similar system.

On the Northern Railway of Spain, level crossings on lines of minor importance are under supervision when the approach of trains cannot be seen from a distance of more than 650 feet before their arrival at the crossing.

In order that level crossings on the Italian State Railways may be left without permanent attendance, it is necessary that the line should be visible from a length in metres equal to :

$$L = l \frac{V}{2}$$

l representing the length of the crossing measured along the roadway, plus the length of the longest vehicles, including the tractors which haul the heaviest vehicles in the district, and V being the maximum speed in kilometres per hour of the lightest trains running on the line.

This formula is based on the assumption that the time taken to pass the length l by a vehicle travelling at 2 km. (1.24 miles) per hour is equal to that taken by a train travelling at speed V to run over the zone of visibility.

If at either end of the crossing there is a gradient of more than 1 in 200, the distance allowed for visibility should be increased 20 %.

Replies from other countries do not refer to conditions of visibility relating to unprotected crossings.

b) *Measures taken to improve visibility or keep it intact.*

Visibility being an essential item for safety at level crossings, it is important that it should be improved if possible, or kept in perfect condition.

The improvement can be made lasting by removing obstacles that hide the view of the line from the road, or relatively by making a certain distance of visibility sufficient by reducing the speed of trains when approaching the crossing.

Clearing away impediments to the field of view at level crossings. — It is the rule in Belgium to remove all trees, shrubs, and tall vegetation growing on railway premises which obscure the sight of trains near level crossings, and to see that such trees and plants do not grow again and become an obstacle to visibility. Hedges and close fencing are replaced by wire fences, and all shrubs removed where there is any chance of improving visibility.

When plantations or private buildings are in the way, and so prevent dispensing with gate keeping, efforts are made to arrive at an understanding with the proprietors so as to clear away any objections.

Permission for planting or building, constructing huts, etc., is always seriously considered before being granted, with the object of having a clear field of view at level crossings.

Similar measures are customary in Denmark, where the Minister of Public Works is authorised to secure land or the rights over land so that reciprocal visibility from the railway and the road may be assured.

Italy, Switzerland, Czecho-Slovakia and Holland have similar rules, and in the latter country it is forbidden to plant trees or construct buildings within a distance of 26 feet on the straight and 65 feet on the inside of curves. The Administration has proposed to the Minister of Public Works that the zone of protection at level crossings should be increased according to a right angled triangle, the side of which along the road is 65 feet long and the one running along the line 1 640 feet long.

A circular from the Administration of the Italian State Railways authorises that, at level crossings, hedges should be cut, trees removed, roads deviated, walls demolished, land appropriated near the line, etc.

A certain number of States in the United States of America have recently introduced laws or regulations forcing the railways to keep their lines free from all plants and trees in the neighbourhood of unattended level crossings. On the other hand, the Country Commissioners must see that the roads are cleared of all vegetation and trees for a distance of 100 feet from level crossings. According to these regulations, it is forbidden to fix any printed notice at a distance less than 500 feet from the crossing.

Limiting the speed of trains. — In order to obtain a sufficient length of time for visibility of the trains, the speed of the latter has been reduced at certain unattended crossings.

This is being done in Czecho-Slovakia, where the absence of attendants is only allowed if the speed of trains does not exceed 25 miles per hour. This limitation has been imposed at certain level crossings where it was desirable to leave them unattended.

Most frequently, however, only a speed limit is fixed above which the gates must be under control. In Italy, for instance, before the application of the recent administrative regulations relating to lines without fencing and with open crossings, speed was limited to 37 miles per hour for trains fitted with brakes, and 28 miles per hour for the others, on main lines, and to 25 or 16 miles per hour for secondary lines.

At the present time the law of 7 November 1920 allows the State Railways to leave without supervision open and level crossings in cases where there is sufficient visibility in relation to the speed of trains, and the amount of traffic on the roads.

On secondary railways in Germany, if the speed of trains does not exceed 25 miles per hour, level crossings are unprotected unless the road traffic is very great and visibility poor.

D. — Warning arrangements at unattended level crossings.

a) *Signals to notify the public that a level crossing is near.*

In nearly all countries these signals take the form of a post fitted with a cross, on the inclined faces of which various indications are inscribed. The signals are placed in the immediate proximity of the crossings, and in places where the field of view is too short as seen from the road, especially as regards automobiles, an advanced signal is sometimes fixed. This method is used in the United States, Canada, Italy, Germany and Austria. Advanced signals are also stipulated in the proposed new regulations in Sweden.

Signals placed in the immediate vicinity of level crossings. — Road signals placed near level crossings are fixed, according to the country, in the following manner :

In Belgium, indicating posts are fitted with a plate on which is inscribed the word « Attention », and on the cross the words « Unattended level crossing ». This is fixed about 50 feet on each side of the crossing (or 33 feet if the road to be crossed is a simple pathway). In addition to this, posts called « barrier posts », painted with blue and white diagonals, are fixed at about 8 feet from the outside rails of the crossings to warn the public when entering the danger zone.

A board bearing the inscription « Beware of Trains » is used in Denmark, and is fixed at such a distance from the line that an automobile can stop before reaching the crossing from the point of visibility of the board.

Similar methods are used in France, Czecho-Slovakia, Switzerland and Sweden.

Unattended level crossings in Holland, Germany and Austria are provided with posts fitted with warning arms arranged as a simple or double cross, according to whether they refer to single or several tracks. In Holland the number of the latter is stated on the lower arms of the warning cross, such as « Two lines », « Three lines », etc., and a notice placed under the cross indicating the speed which vehicles must not exceed when crossing the track. In addition to this, the posts in Austria are fitted with a board bearing the inscription « Stop if a train is approaching ». In the centre of the cross the international sign denoting a barrier is fixed.

There are two kinds of warning posts in Italy, one for crossings of minor importance, and the other for important crossings. The first consists of a post on the top of which is a board, 4 feet wide, below a skull and cross bones, on which is inscribed « Beware of Trains ». The second carries in its centre the skull and cross bones, and above a cross with arms 8 ft. 2 in. long, one of which carries the inscription « Beware of Trains », and the other the word « Danger », repeated on each side of the post.

In the United States and Canada, all level crossings, even if they are attended, are protected by signals in the form of a post on the top of which is a cross with sloping arms, bearing the inscription « Level crossing », « Beware of the Locomotive », or « Stop — Look — Listen ». These signals are placed at points most easily visible to those approaching the crossing.

Advanced signals. — Advanced warning posts in Italy are reserved for level crossings of great importance. They are placed at 820 feet from the crossing, and are only a repetition of those placed in the immediate proximity of the latter.

Distant warning signals in Germany and Austria consist of a post carrying half a cross (V), and provided with the international sign, and are fixed on the road 820 feet from the crossing. They are used in Germany on roads frequented by automobiles, heavy wagons, or cattle and in Austria in special circumstances, such for instance as when the presence of houses obstructs the view of the warning post near the crossing.

In certain States of the United States of America, on important roads, the ordinary warning signals are preceded by an advanced signal in the form of a disc 2 feet in diameter, which carries a vertical cross and the letters « R. R. » painted in black on a white background. This signal is placed at a distance of not less than 300 feet from the crossing. Other American States recommend the Railway Administrations to fix on the roads at variable distances from the crossings danger signals, carrying in large red letters on a white background

such terms as « Main Line — Danger », « Stop », or « State Law — Stop », etc.

In Sweden, a recent ministerial decree relating to the automobile service, recommends the authorities responsible for the upkeep of the roads to fix advanced warning posts at crossings frequented by automobiles.

b) *Signals warning the public of approaching trains.*

When the field of view is wide enough, the signals mentioned above are sufficient to assure safety, but if it is not, the necessity arises to add signals announcing the approach of trains.

These signals may be either audible or optical, the former being given by the engine drivers whistling when approaching the crossings.

In some countries (Argentine, Austria, Denmark, United States, Norway, Switzerland), engine drivers are warned by special signals of the places where they should whistle or ring a bell fixed on the locomotive (United States, Denmark) so as to announce their approach. These signals take the form of notice boards fixed at a suitable distance from the crossing, and on which is generally inscribed the word « Whistle ».

In Denmark these signals should be so placed that the lights of the locomotive may make them visible at night time. Holland, and the Association of German Railways, consider it too much to expect the drivers to whistle at every level crossing.

In Austria, warning signals are not expected to be given except in times of fog.

Another form of audible signal consists of bells, which announce to the public the approach of trains. These are put into action either by employees attached to the stations or signal boxes at a certain distance from the crossings, or by the trains themselves on reaching such a distance from the crossing that it would be dangerous for the public to cross at that particular time.

Belgium only makes use of bells at crossings where traffic is quite small, and Switzerland where road traffic is insignificant. In both countries bells are additional to the warning posts.

Audible apparatus is also in use in Sweden.

In a few cases in the Argentine, notices with warning whistles are fixed on the permanent way.

The United States, Canada, Italy and Switzerland also use audible apparatus combined with optical apparatus to announce the approach of trains, and to which we will refer later.

In America (United States and Canada) it is thought that electric bells are not suitable for warning of automobiles, the noise of the engines preventing their sound being heard unless it is exceptionally loud. They are also inconvenient in congested places, the inhabitants of which are annoyed by the noise they make. For these reasons, the use of electric bells is generally limited to crossings on small lines on which there is little traffic in sparsely populated districts.

Mr. Maas Geesteranus states that in the countries with which his report deals the same objections are raised to the bell arrangement, and adds that their action is not so certain as luminous signals, and they are less easily noticed for instance during storms, in the neighbourhood of waterfalls, by drivers of noisy conveyances, or by individuals who suffer from deafness. Consequently luminous signals are preferable.

The latter are generally combined with ordinary optical apparatus fixed near the crossings, and give one or more red lights, either fixed or scintillating, at the approach of a train. Others show a green light when the crossing is clear.

There are four principal kinds in use : *Siemens, Aga, Wig-Wag,* and *Carlo-Concato.*

The *Siemens* type has been tried in Italy, and consists of an ordinary indicating apparatus, a lamp which lights and a bell which sounds when a train closes an electric circuit by means of a mercury pedal arrangements. This apparatus has the serious inconvenience of not working in case of a breakdown, and gives no indication that it has failed.

The *Aga* apparatus used in Switzerland has a scintillating light fixed on the top of an ordinary warning post between the inclined arms of the cross and the international sign indicating a barrier. This light, given by an acetylene lamp, shows red when a train passes, and green when the crossing is clear. A similar apparatus is in use in Sweden.

There are several varieties of Wig-Wag warning signals, such as those of the Italian Signal Company, the Magnetic Signal Company, and that adopted by the American Railway Association. Their chief characteristic consists in an oscillating red disc, generally carrying the word « Halt », with a red light and bell. When the crossing is clear, all is stopped and silent, but at the approach of a train the lamp lights and the bell rings, the whole being put into action electrically by the approaching train.

In some of the *Wig-Wag* apparatus the disc is hidden when the crossing is clear by means of a screen bearing the inscription « Beware of Trains », and when the apparatus is out of order the movable disc remains visible in a vertical position. (Italian Signal Company; Switzerland; American Railway Association.)

In other kinds the movable disc remains visible and in the vertical position both when the crossing is clear and when the apparatus is out of order (Italy : Magnetic Signal Company).

The *Wig-Wag* apparatus is in use in America, and on trial in Italy, Belgium, Sweden and Switzerland, the American type being fixed in the three latter countries.

The *Carlo-Concato* warning signal consists of a framework stretching across the road near the level crossing, and carrying in its centre below the notice « Beware of Trains » a certain number of lamps, which light up when a train approaches.

It is fitted also with a bell, a klaxon, and a death's head sign, and can show three different signs as follows :

When the crossing is clear, the red lights are extinguished and the apparatus is silent;

When a train approaches, the red lamps light up and the sound signals become audible;

Should there be anything faulty in the working of the apparatus, the death's head appears. This system is on trial in Italy.

There are other systems which are simpler. In America, scintillating lights are shown, two of which are red, when a train approaches, alternating along a horizontal line, or a series or red lights appear one after the other, forming an arc of a circle. These lights are worked either from relays or motors, and are often accompanied by bell arrangements coupled in the same circuit.

In Austria, when it is considered necessary, luminous signals are added to the cross-shaped warning signals, giving a red light towards the road when a train is approaching the crossing.

Economical results.

The economy realised in wages by administrations who have already dispensed with gate keeping at many of their level crossings amounts to a considerable sum. The best results are shown by the Belgian State Railways, who by this means make a saving of

5 000 000 francs per year. Holland, having abolished gate keeping at about a thousand crossings (about half of which were barriers worked from a distance) has made a yearly economy of about one and a half million florins; Sweden half a million crowns; and the Italian State Railways, by dispensing with gate keeping at about 6 000 crossings, save about 48 million lire each year.

The yearly saving per crossing arising from dispensing with gatekeeping is estimated at about 1 000 crowns in Sweden, 2 000 to 5 000 francs in Switzerland, 1 000 francs in Portugal, and 750 to 3 000 dollars in the United States.

By the side of these figures should be placed the cost of installation and upkeep of warning apparatus when this is charged to the Railway Administration.

The Italian State Railways give the cost of fixing warning posts near level crossings at 250 lire, and the average annual maintenance cost at 25 lire.

The cost of fixing signals announcing the approach of trains is much greater, being from 20 000 to 25 000 lire, according to the type, giving indications in both directions of the road.

Similar apparatus in the United States is estimated at about 1 800 dollars, with a yearly upkeep cost of 100 dollars.

Mr. Maas Geesteranus states that as regards the responsibility for costs relating to fixing and maintenance of apparatus to warn users of the road of their proximity to level crossings and the approach of trains, this was, according to those who replied to his enquiry, borne by the Railway Administrations.

The same system applies to the Italian State Railways, and Mr. Mendizabal considers that the cost of fixing and maintaining warning signals should be divided equally between the Railway Administration and the authorities responsible for the roads.

The cost of fixing and maintaining automatic warning devices in the United States is borne by the Railway Companies. In some cases, however, the State shares a part of the expenses that may be occasioned by additional protection, such as automatic warning signals fixed on the great State roads that are considered requisite by the Commissioners of Public Service, who finally decide all questions of this kind.

SUMMARY, AND VARIOUS REMARKS.

To sum up, it will be seen that nearly all countries are occupied in dispensing with gate keeping at level crossings, especially on lines with small or average traffic.

In order to allow or facilitate this reform, it is sometimes necessary to alter the law or the administrative regulations relating to level crossings. This has been the case in Holland and Italy.

A large amount of gatekeeping has already been abolished in certain countries, such as Belgium, Holland, Sweden, Switzerland, Italy, United States, and Canada.

Generally speaking, this abolition of gate keeping has mostly been applied at crossings of small or average importance, and is made clear to users of the road by means of sign posts, preceded where necessary by advanced posts, and accompanied — where the visibility of the line is considered insufficient — by signals announcing the approach of trains. There are several kinds of these signals which have been adopted or are on trial, and they appear to give every satisfaction.

Mr. Maas Geesteranus gives a very simple definition relating to the conditions of visibility that are necessary or sufficient to enable vehicles of every kind, as well as pedestrians, to cross the danger zone in less time than it takes a train to run the distance from when it is first noticeable. He considers that in

order for warning and advanced signals to be quite visible it should be possible to see them at a distance of 33 feet at the least on roads of small importance, and at 230 feet on roads that are much frequented, especially by automobiles. He recommends that in those places where gate keeping has been abolished, this should be conveyed to the public by giving instructions as to the precautions that should be taken when crossing, such as : approach slowly, stop, look round, listen, pay attention to trains that might cross one another on double lines, etc., and remember that administrations are not responsible for the consequences of any accidents that may happen if these rules are not observed.

Mr. Maas Geesteranus also recommends that different signals should be used to announce the approach of level crossings that are provided with or are without attendants, and points out that in the latter case it would be an improvement to make some modification to the international signal which indicates the approach to a barrier. The same observation is made in the other European reports, and it is quite evident that a driver, having seen a notice indicating proximity to a barrier and not seeing one, concludes that the crossing is clear, and so may be led into a trap and perhaps struck.

Mr. Maas Geesteranus gives special attention to the case where level crossings are under control during only part of the day, and is of opinion that it would be better in these cases to fix changeable signals, indicating that the crossings are not under supervision, which could be seen only while the attendants are absent. This is, according to Mr. Ray's report, the general custom in the United States.

He also points out that only Holland, Austria and Germany indicate on warning signals whether the road crosses a railway of one or more tracks, and he considers this indication is very useful in the interest of safety, and should be made general.

Finally, he remarks that warning posts are not generally provided with lights, but in Holland the problem has been very simply solved by fitting them with red reflectors which reflect the light from the lamps on the vehicles.

Mr. Mendizabal considers that the new official edicts promulgated in Italy are modern, clear, precise, and arranged in the most practical way to abolish on a large scale the supervision of numerous level crossings; they depend greatly on the intelligence and knowledge of the users of the road, which is manifestly a sign of progress.

He notices that the Spanish and Portuguese Administrations, who have not yet been able to dispense with gate keeping, are favourably disposed towards doing so.

It would be better, he says, if level crossings that are under supervision could be indicated from a suitable distance on the road in order to avoid barriers being struck by mechanically driven vehicles, but as regards crossings which have always been without attendants, he thinks there is no necessity to provide them with signals or warning apparatus on account of their small importance.

According to the report sent in by France, which completes those from Europe, the great French Railways are unanimous in their opinion that a prudent and progressive application of the system of gradually dispensing with gate keeping at level crossings, where this can be done, would give great economical advantages without danger to the road traffic.

Finally, Mr. Ray declares that in the United States many of the States have passed laws creating commissions vested with wide powers to deal with the public services including railways, and

measures of general interest, especially all that relates to level crossings, such as construction, modification, clearing away obstacles which hinder visibility, signalling, circulation of vehicles, etc. For instance, in certain States every motor driven vehicle must come to a stop before crossing the railway lines at a public level crossing. It is certain that such a method would be of great assistance so far as safety is concerned.

Mr. Ray adds in conclusion that the protection of level crossings by means of automatic signals is being accepted with increasing favour in America, and the public authorities are actually disposed to allow its adoption to take the place of attendants on roads where the density of traffic is not the chief factor.

FINAL SUMMARY.

The statements of the reporters may be summed up as follows :

1° The abolition of gate keeping gives important economical advantages, and causes no inconvenience to crossings on roads where the traffic is not too great, and where the field of view of approaching trains from the road is sufficient in all directions;

2° The approach to level crossings, the supervision of which has been abolished, should be notified to users of the road by signals that are visible day and night where necessary, and which allow drivers of the fastest running vehicles likely to use the crossings, to stop before reaching them. In cases where the field of view is insufficient, these signals should themselves be preceded by advanced signals placed at suitable distances from them. It is advisable that these signals should indicate the number of tracks that have to be crossed.

The international signal announcing the approach to a level crossing is not suitable for unattended crossings.

3° Even in those cases where the visibility of trains as seen from the road is insufficient, abolition of gate keeping may take place without inconvenience, on condition that automatic apparatus announcing the approach of trains is placed near the crossings;

4° Level crossings at which gate keeping is dispensed with during part of the day should be provided with special warning apparatus similar to that used on unattended crossings, but hidden from the public view during the period the crossings are under supervision;

5° A good automatic warning signal working at all hours of the day and night offers a much greater guarantee of safety at nearly all level crossings than the protection given by gate keepers or attendants during a part of the day only;

6° Automatic apparatus announcing the approach of trains, having two scintillating lights placed on each side of a central supporting post, and fitted with oscillating signals that can be depended upon, is the best form of automatic signal;

7° Automatic signals that announce the approach of trains should, if the apparatus fails or gets out of order, show to road vehicles a danger signal visible both day and night.

It is desirable that they should not be influenced in the vicinity of stations by operations which do not concern the crossings;

8° Audible warning signals are not so serviceable as luminous signals, and are only justified at isolated crossings of small importance;

9° It is desirable that signals announcing level crossings and trains should be of standard type and international, so

that their indications may be understood and respected by all.

The general use of red lights in streets and as rear signals on automobiles should be prohibited. Such lights should only be used on roads at points where there is real danger, such as level crossings;

10° The Congress might adopt a motion inviting countries, the Railway Administrations of which are members of the International Association, to issue a recommendation that with rare exceptions, gate keeping at level crossings should be dispensed with when local circumstances — such as visibility — are favourable, without considering the importance of the crossing;

11° The cost of fixing and maintenance of announcing apparatus at level crossings where supervision has been dispensed with, could be distributed between the Railway Administrations and the authorities interested in traffic on the roadways;

12° With the reservations mentioned above, opinion should be influenced so that the public may see to its own safety when negotiating level crossings.

[625 .143.5 & 625 .143.4]

QUESTION II

(Breaking of rails. — Joints) (1),

By Mr. MERKLEN, special reporter.

The above question has been the subject of four reports :

Report No. 1 (America), by Mr. W. C. Cushing (2);

Report No. 2 (British Empire), by Mr. C. J. Brown (3);

Report No. 3 (France), by Messrs. Merklen and Cambournac (4);

Report No. 4 (other countries), by Mr. J. Willem (5).

The particulars supplied by the various administrations that have replied to the list of questions sent to each, have enabled the reporters to summarize their investigations as follows :

A. — BREAKING OF RAILS.

I. — SUMMARY OF THE REPORT OF Mr. W. C. CUSHING.

(AMERICA.)

A distinction is drawn between « rail failure » and « broken rail ».

In the United States and Canada, the general and comprehensive term for a rail that is considered unfit for further use in the track by reason of a suspicious defect, is « rail failure », which is used even though the rail may not be broken.

« Broken rail » is only a sub-division of « rail failure »; when a rail shows the slightest suspicious defect, it must be removed from the track and reported as « rail failure ».

1. — Breakages attributable to the use to which rails are put.

Effect of wear. — A rail may be taken up before it has worn appreciably because it may be needed for a line having lighter conditions of service. There is no general rule determining the limit of wear. For this reason, the wear of rails as a factor of rail breakage in service, is not of much importance.

(1) Translated from the French.

(2) Vide *Bulletin of the International Railway Congress Association*, Number of October 1924, p. 677.

(3) Vide *Bulletin of the International Railway Congress Association*, Number of May 1925 (1st part), p. 1163.

(4) Vide *Bulletin of the International Railway Congress Association*, Number of May 1925 (1st part), p. 1289.

(5) Vide *Bulletin of the International Railway Congress Association*, Number of May 1925 (1st part), p. 1403.

Engineers, however, are studying the subject of obtaining greater resistance to abrasion, in order to effect economy in renewals. Special alloy steels or carbon steels, heat treated have been tried.

The most important of these experiments relate to manganese steel rails, in which the percentage of manganese has been raised from 10 to 14 %. But owing to its high cost and its low elastic limit, the trials have not been carried further; a certain number of breakages have been reported as well as insufficient resistance to crushing and hammering. Actually, no definite result has yet been obtained.

It is possible that the properties of special steels which may be suitable for producing rails of high elastic limit, which are not brittle and yet strong and tough, have not yet been fully developed.

Elasticity of the road-bed. — No particulars have yet been submitted relating to the influence of the elasticity of the road-bed, but attention was called to the fact that there are more rail breakages in winter than in summer; the reporter does not think that the rigidity of frozen ballast is the real cause of the breakages; the cause lies rather in the difficulty of maintaining the tracks during extreme cold.

The inclination of the rails, the gradients up or down, the spacing of the sleepers, and corrosion, do not appear to have any influence on the number of breakages of rails.

Breakages at the fish-joints. — The proportion of fractures that occur at fish-joints varies from 3 to 75 % from one railway system to another. The small proportion of 3 % mentioned by the New York Central can be attributed to the use of an angle-iron fish-plate 950 mm. (3 ft. 1 3/8 in.) in length, resting on three sleepers, one of which comes under the joint. This railway system is the only one using this system of fishing.

2. — Rail breakages attributable to defects in the rail metal.

The reporter reviews the various stages in the evolution of the shape of the rail section and of the chemical and physical properties of the rails.

After having quoted the trials and careful researches of Dr. P. H. Dudley, which had led to the opinion that rails of soft steel present the greatest resistance to wear (the investigation on the same subject made by Mr. Frémont in his 69th paper leads to the same conclusion) he quotes an important investigation of the 1885 Committee of the American Society of Civil Engineers (A. S. C. E.) on the same question, the conclusion arrived at being the following :

It is none the less true that it is a well known fact that the present heavy rolling stock crushes the superficial structure of Martin steel rails and forces the metal to flow.

Chemical composition of rail steel. — The percentage of carbon required for rails weighing 70 to 80 lb. per yard, 0.53 to 0.68 %; for 85 to 110 lb. per yard, 0.62 to 0.75 %; 111 lb. and upwards, 0.67 to 0.80 % — of phosphorus a maximum of 0.04 % — of manganese, 0.50 to 0.90 % — of silicon a minimum of 0.20 %.

Piping and segregation. — This question, which has been considered as of great importance, has already been discussed by the reporter.

Segregation is nearly always accompanied by other defects : brittleness and hardness.

The segregated rail which flies into many pieces suddenly under a train is the most dangerous failure with which we have to deal. A fair measure of the segregation may be expressed by the analysis (Pennsylvania Railroad method) but in order that this specification may be adopted, it has been necessary to fit up a car with the chemical

apparatus required, and appoint a staff of chemists who carry out the analyses at the rolling mill, while the rails were being rolled; it was necessary to pay an extra charge to the manufacturer for permitting this to be done.

The remedy appears to be in better manufacture, particularly by the use of a sink-head in casting ingots, and by making the upper end of the ingot the larger end.

The specification reprinted at the end of the report requires that a sufficient proportion of the ingot shall be cut off to remove all traces of segregation, and to ensure homogeneity in the rails.

Transverse fissures. — In this important chapter, which should be read as a whole the reporter studies transverse fissures inside the metal itself, which we class under the name of « oval silvery spot », and which have also been studied by Mr. Frémont in his 69th memoir.

This defect is to be found in rails of all ages and from all sources, whether of Bessemer or Martin steel, and 20 % of rail breakages are attributable to this cause.

It would appear that the origin of this defect lies in the presence of numerous small internal cracks, the origin of which is presumed to be due to the method of manufacture.

The reporter calls for the co-operation of the large railway systems and of the rolling mills in the investigation of this important question.

3. — Rail sections-heavy rails.

The failures of 100 lb. rails are two and a half times more numerous than the failures of 130 lb. rails. It is estimated that the life of the 130 lb. rails will be from 20 to 30 % greater than that of the 100 lb. rails.

4. — Rail steel.

Notwithstanding the increase in weight of the rails, failures continue to occur, but in decreasing number; the fractures that have been found show that the remedy must be sought rather in the quality and the tensile strength of the metal than in increasing the weight per yard.

Experiments have been made of special steels of high manganese content, and also with chrome nickel steel; but these trials of chrome nickel steels were made on metal which had not been heat-treated, and the results were divergent, some being very unsatisfactory; manganese steel was only used because of its presumed power of resisting wear.

Rails produced by the electric hearth process were tested and no marked advantage was found.

Trials made on rails obtained from ingots with a large runner and the wide end of the ingot at the top, have given particularly satisfactory results, the reduction in the number of fractures being in the ratio of 200 to 63.

The rails treated by the Sandberg process appear to show greater resistance to wear; but they have not yet been in service for a sufficiently long time to enable any definite conclusion to be reached.

To sum up, twenty-five years of research has not resulted in complete satisfaction, and though there have been improvements, much still remains to be done.

5. — Heat treatment.

Trials of rails that have been subjected to complete heat treatment have been made on the Pennsylvania Railroad with satisfactory results. The increased resistance to wear has been from 12 to 64 % on carefully treated lots, and only a single fracture has taken place.

Actually, the results obtained are very encouraging; it only remains to make the manufacture a practical proposition.

It is probable that in addition to heat treatment, it will be necessary to spe-

cify that the ingots should be cast with large risers.

6. — Specification for rails.

An examination is being made into the possibility of classifying the rails, according to the results of tests, as rails of different qualities; the better qualities will be reserved for the more important lines.

7. — Guarantee of rails supplied.

At one time rails were guaranteed by the manufacturer for a period of five years, but this guarantee has not been in force for some time, as the result of the increase in the weight of the rolling stock.

At the present time, some railway systems are asking for the restoration of the guarantee, others think that the manufacturer should share the expense occasioned by failure of rails in service, while others think that the manufacturer should be responsible for the consequences of an accident caused by a defective rail should the results of the enquiry show that the defect could have been avoided by better methods of manufacture.

SUMMARY.

1° The sectional designs or profiles of rails have passed through several stages, embodying *a*) on the one hand heavy and moderately wide heads and thin bases with rather low stiffness, and *b*) on the other very thin and wide heads and also the extremely thin bases with maximum stiffness, to the compromise types of American Railway Engineering Association, characterized by a well balanced section with wide and moderately thick head and much heavier base with a high degree of stiffness, rather favoring the second type above.

2° The density of traffic has increased so mightily, and the concentrated weights of rolling stock have become so large, that the intensity of pressure upon the bearing surface of the rail-head and the tensile stresses inducing strains of rupture in the interior of the head of the rail have imposed conditions of service which are difficult for rails of Open-hearth carbon steel to withstand, especially as,

3° There are processes of rail manufacture at the mills imposing thermal conditions, resulting in some melts having minute shattering cracks in the interior of the rail-head, which are enlarged to final rupture of the rail in service when the character of that service is very severe.

4° Rail designs or profiles having been well proportioned physically and metallurgically, and specifications having been brought to the degree of improvement in the art considered practicable, the railroad companies with severe service conditions are upon the threshold of additional research into the materials and methods of rail manufacture which will satisfy the new demands.

II. — SUMMARY OF THE REPORT OF Mr. C. J. BROWN.

(BRITISH EMPIRE.)

1° The primary cause of fracture when it is not due to excessive wear or to abnormal climatic conditions, may be chiefly attributed to :

a) Chemical or mechanical character defects in the steel.

b) Weakness of the track at the joints and in their immediate vicinity.

2° The relatively small number of rail fractures, on the railways forming the subject of this report using steel of a quality equivalent to that required by

the British standard specification, does not appear to justify making of any modification in the requirements of this specification.

3° Attention should still be given to improvement in the methods of manufacture with a view to the ultimate elimination of the defects that the rails may have, such as flawed rails, segregation, and other chemical and mechanical defects existing in the metal.

4° The best method for reducing the number of fractures attributed to wear of the rails, appears to be that of careful maintenance of the track, particularly at the joints and in their vicinity.

5° The number of joints in the track should be reduced to the minimum by adopting a length of rail as great as the circumstances will allow.

6° It is not advisable to endeavour to make the steel manufacturers responsible for damage resulting from rail fractures due to defects in material or due to the action of the rolling loads.

III. — SUMMARY OF THE REPORT OF Messrs. MERKLEN and CAMBOURNAC.

(FRANCE.)

It has been found from the replies received from the greater number of railway systems, that the initial causes of rail fracture are always the same; piping, segregation, zones of small blowholes, slag enclosures, excessive brittleness, extremely fine cracks existing in the new rail that have escaped notice in the inspection at the works, or defective machining of the rails used for the construction of points and crossings.

But the railway systems add that they are generally badly equipped for the investigation of the first causes of fractures of rails, and their opinions are based on the classic investigations made many years ago by a Frenchman, Mr. Charles Frémont, the results of which were published in his memoirs, No. 58 (« Causes of Premature Wear of Rails » (1). No. 61 (« Causes of Accidental Fracture of Rails ») (2), and No. 69 (« Wear & Defects of Rails ») (3).

The remedy for all these initial causes consists primarily in obtaining steel manufactured with ever-increasing care.

It appears that this will be attained in the following manner :

1° Research by the railway systems into the primary causes of each rail fracture, by exhaustive examination of the sections of fractured rails : this examination should be made in a properly equipped laboratory which should produce a report analogous to those made by Mr. Frémont, for each fractured rail.

From the whole of these reports, it would be possible to draw conclusions that would enable modifications or additions to be made to the specifications, and in particular would lead to improvements in the specified impact test on a bar taken from all ingots as inserted in the standard specification of the large French railway systems, with the object of ensuring that the segregated portion of the ingot is removed.

2° It would be necessary to establish close collaboration between the works and the representatives of the railway systems, the latter confining themselves to making investigations and communicating the results of these investigations to the technical experts of the steel makers. The representatives of the railway

(1) « Causes d'usure prématurée des rails ».
(2) « Causes des ruptures accidentelles des rails ».
(3) « Usure et défauts des rails ».

systems would avoid passing any criticism on any method of manufacture as they would not be qualified to take part in a technical discussion of a subject of which they had only partial knowledge. They would, however, independently of the ordinary tests, proceed, for example, with the necessary macrographic tests for ascertaining the homogeneity of the metal in the accepted part of the ingots. The required cropping of the heads of the ingots made with the object of eliminating that portion of the ingot that contains excessive segregation, should, however, prevent a macrograph showing evidence of much segregation.

In order that it may give useful results, the macrographic examination should be carried out on the metal itself, for example by the iodine reaction, and not on bromide paper prints (Baumann test), obtained by contact with the metal. The latter do not always show the existence of extremely fine craks running from one impurity to another, cracks that are only rendered visible on the metal itself by the use of high magnification.

The Baumann test, moreover, does not show the different variations in the metal that may exist in a particular section of rail, but which, on the other hand, appear extremely clearly, on metal treated by the iodine reaction.

We should recognize that the works always accept fair criticism with goodwill, and interest, even when some of the facts discovered lead to unforeseen expenditure. To reduce the cropping and the number of rejects, it would be desirable that the steel maker should continue to make efforts for securing complete elimination of piping and segregation. Comments made to the makers it would appear should also deal with brittleness of the metal which renders internal fissures much more serious, and which is one of the causes of rail breakages at the rail joints. A large number of observations made on cases of brittleness may perhaps lead the railways and steel makers to introduce, by mutual agreement, tests of brittleness in the specifications.

The fish-joint is one of the chief of the secondary factors of rail fracture. It would therefore be well to investigate methods of improving it particularly with the object of abolishing the shock effect which is absent in the clear part of the rail. From this point of view, it would appear to be of interest to increase the number of experiments with rail-joints which appear to give the greatest satisfaction : bridge joints, wedged joints without bolts, and joints supported on sleepers.

We think that in concluding we should draw attention to the answers sent in on the following two questions :

1° Statistics giving the annual number of rail breakages on each railway;

2° Under what conditions and within what limits the specifications lay the responsibility on the vendors in case of accidents arising from a rail breakage, when the enquiry attributes this to any cause other than the use to which the rail has been put by the railway, that is to say, to a defect in the metal of the rail.

As far as concerns the first question, the answers sent in show that the number of annual breakages per kilometre of track and for an equal density of traffic, differs widely on the various railways.

As all the essential factors, such as quality of the metal, conditions under which used, etc., appear to be identical on all the railways, one can only attribute the difference in the number reported to the more or less rigorous preventative measures taken before total fracture occurs. It is possible, in practice, that the number of defective rails taken out of the track before total fracture occurs is much greater on the railways which report a relatively small number of

breakages. We think in conclusion that it would be interesting to compare the practice of the railways as regards the removal from service of damaged or doubtful rails, and to draw up a standard rule modelled on the strictest regulations in use on this subject.

As regards the second question, opinions are very much divided, but it would appear from all the answers sent in that this may be a matter of common law, even in cases not covered by the guarantees required in the specifications.

Under these conditions, the question, which would appear to be one for the legal department, does not appear to be one for which there is any universal ruling which is applicable to all countries.

IV. — SUMMARY OF THE REPORT OF Mr. J. WILLEM.

(OTHER COUNTRIES.)

1° It will be necessary to come to agreement, with regard to fracture or failure of rails, on a very definite classification which will serve as a basis for the statistical records.

2. — Age has an effect on the quality of rails : it appears that the phenomena of re-crystallisation found in metal bars long after they have been put into service, and the modifications of texture found in pieces of the metal under the action of repeated shock, should show themselves in rails that have been a long time in service.

3. — The wear of rails, the elasticity of the road-bed, cold, the inclination of the rails, the section (curves and gradients) of the line, and corrosion, have not given rise to any points of interest.

4. — Fractures of rails occur more frequently at the fish-joint than in the clear portion of the rail; the Netherlands State Railways consider the ratio to be seven to one. Various railway systems find that fractures occur more often on the end of the rail on to which the wheel runs, than on the end of the rail which the wheel leaves.

5. — Many railway systems abstain from specifying chemical composition; others specify compositions varying as follows :

Carbon, 0.45 to 0.75 %;
Silicon, 0.25 to 0.20 %;
Manganese, 0.80 to 1.10 %;
Phosphorus, 0.06 to less than 0.08 %;
Sulphur, 0.06 to less than 0.07 %,

the adoption of a minimum percentage of silicon appears to have taken place recently.

6. — Piping, with segregation, is the most frequent cause of rail fracture; the precaution to be taken is sufficient cropping of the ingot.

Segregation may cause trouble, sometimes immediately, and sometimes after many years. The findings of Mr. Frémont, given in his papers on fractures of rails, are identical with those which have been brought to the notice of the reporter.

Owing to the obvious inadequacy of the methods of inspection usually laid down in the specification, it appears that these should be supplemented by impact tests and by macrographic and micrographic examination, to be decided after investigation of the question by experts in these matters.

7. — Many railway systems have recently used sorbitic rails, but are unable

at present to give information on the results obtained. The Belgian State Railways had laid some trial sections of sorbitic rail, of titanium steel rails, and of electric furnace steel rail, but the war interrupted the experiments, and prevented any practical information being obtained.

8. — The majority of railway systems require a guarantee ranging from six months to five years; others, and not the less important, have given up all guarantees.

The reporter is of the opinion that the common law should suffice.

GENERAL SUMMARY.

The findings and recommendations relating to the question can be summarised as follows :

I. — Examination of the replies relating to breakage of rails supplied by the various administrations has been made difficult and their comparison impossible on account of the differences in the regulations of the respective administrations under which statistics are drawn up.

It seems desirable that common regulations dealing with the matter should be adopted on the following lines :

A) Definition of breakages. — A rail should be considered as broken when completely separated into two or more portions, or when a piece of the head is broken off causing an interruption of the running surface.

B) Classification of breakages according to the weight of the rail per unit of length : These should fall into two categories, one including heavy rails of weight greater than 42.5 kgr. per metre or 85 lb. per yard, and the other including light rails of weight equal to or less than 42.5 kgr. per metre or 85 lb. per yard.

C) Classification of breakages, according to the age of the rails, in the track, *viz.:* Those having less than 5 years, from 5 to 10, from 10 to 15, from 15 to 20, and beyond 20 years.

D) An index number of the breakages: The total number of breakages, without distinction of weight and age of the rails, on each administration, in relation to traffic density by giving the number of breakages per 10 000 000 kilometre trains or 6 250 000 train miles.

E) The information under *D*) to be supplied for each year on the annexed form and sent yearly, before the 31 March of the ensuing year, to the Permanent Commission who will combine the replies for common publication.

II. — It appears desirable, in order to follow up the study of the question, that administrations should classify breakages both for « heavy » and « light » rails in such a way as to give at least the following particulars :

A) Percentage of breakages in the respective portions of the rails covered by and clear of the fishplates.

B) Percentage of fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section;

1° With « silvery oval spot ».
2° Without « silvery oval spot ».

b) Fractures, part of which are old and strongly oxidised extending to the outer face of the foot or head of the rail :

1° When the oxidised part is in the foot;

2° When the oxidised part is in the head.

c) Fractures with strongly oxidised portions not extending to the outer face of the foot or head of the rail.

III. — It appears desirable that the

. . . . *Railway*

Fractures of rails occurring during the year . . . . .

DESCRIPTION OF RAILS.	*Age of rails :*									
	less than 5 years.			*5 to 10 years.*				*more than 20 years.*		
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.		Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.
Heavy rails, of a weight equal to or greater than 42.5 kgr. per m., or 85 lb. per yard.	. . . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . .	. . . . .	. . . .	. . . .
Light rails, of a weight less than 42.5 kgr. per m., or 85 lb. per yard.	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . .	. . . . .	. . . . . .	. . . . . .
Total. . .	. . . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . .	. . . . .	. . . .	. . . .

Number of train-kilometres or train-miles. . . . .
Total number of fractures . . . .

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles . . . .

railway systems should take the necessary precautions for proceeding, either on their own account, or in collaboration with the steel works, to an investigation of the initial causes of fracture of rails. In particular, it would appear desirable to study the failures that occur through « transverse fissures », a defect that is known in France by the name of « silvery oval spot » (tache ovale argentée), the primary cause of which is not thoroughly understood.

IV. — The segregation found in the metal of the greater number of fractured rails appears to be the most frequent primary cause of the fractures observed; the attention of steel makers should be directed to the necessity for continuing to endeavour to secure the total elimination of segregation of the metal, and it is necessary that provision should be made against segregation by suitable requirements laid down in the specification.

V. — Macrographic tests tend to facilitate examination for segregation. It would be desirable to extend the use of such tests, and improve them, so as to make them of practical service in the inspection of rails. The same remark applies to tests on resilience.

VI. — The heat treatment of rails appears to have the effect of improving the quality of the metal and reduces its brittleness. It would be of interest to follow up the experiments made with heat treated rails.

VII. — Among the secondary causes of rail breakages, the most important must be considered to be shocks produced at the joints by the rolling loads. It is advisable therefore :

A) On the one hand to increase the length of rails so as to reduce the number of joints, and

B) On the other hand to improve the design of joints so as to suppress or reduce the shocks caused by the passage of the wheels.

VIII. — It appears possible to prevent to some extent breakages in rails by very careful maintenance of the track and the exercise of close inspection of the material forming it, so as to enable rails to be removed as soon as they begin to develop flaws which may result, before long, in breakages.

B. — RAIL JOINTS.

I. — SUMMARY OF THE REPORT BY Mr. W. C. CUSHING.

(AMERICA.)

1. — Strength and rigidity of the fish-plates have been considerably increased:

a) By improvement in shape of the fish-plates;

b) By the use of Martin steel instead of Bessemer steel;

c) By heat treatment of the steel with or without additional alloys.

2. — The use of steel which has been heat-treated has given the joint a strength almost equal to that of the rail itself.

3. — The improvements mentioned above have reduced fractures at joints to an almost negligible amount.

II. — SUMMARY OF THE REPORT OF Mr. C. J. BROWN.

(BRITISH EMPIRE.)

1. — The ordinary suspended joints at present in use both for double-headed and Vignoles rails, are simple and inexpensive, but have the defect that they form the weakest part of the track.

2. — A more perfect type of joint is desirable. It is, however, essential that it should consist of few pieces, which should be as simple as possible, and that it should not be costly for installation or maintenance.

3.— The supported type of joint would be possible provided that it distributed, over the sleepers on each side of the joints to an equal extent, the forces due to the rolling load that runs over the joint.

4. — Annual unscrewing of the bolts and nuts, and lubrication of the fish-plates is advisable.

5. — When it is necessary to take precautions against creeping of the rails, these arrangements should be independent of the joint.

6. — The normal length of rail should be as great as the climatic conditions and conditions of supply permit; by this means, the number of joints in the track is reduced to a minimum.

7. — The reconditioning of bolts and worn fish-plates may be justified in special cases.

III. — SUMMARY OF THE REPORT BY Messrs. MERKLEN and CAMBOURNAC.

(FRANCE.)

1. — The type of joint most in use or which the French railway systems are tending to adopt, is the suspended joint arranged midway between two adjacent sleepers, and formed of flat fish-plates of heavy section, but not of the carrying type; the joints in the two lines of rail are opposite, that is to say, on a line perpendicular to the direction of the track, or not staggered; the normal length of rails is from 18 m. to 22 m. (59 feet to 72 ft. 2 in.).

2. — The general tendency is to free the joint from any arrangement intended to prevent creeping of the rails under the action of the rolling load or of braking.

3. — Various types of joints differing from the general type described above, have been adopted or tried by the French railway systems; amongst these joints may be mentioned as of special interest :

a) Bridge joints, in which the ends of the rails rest on a fish-plate of special form, which forms a bridge between the two sleepers adjacent to the joint;

b) Joints in which the sleepers adjacent to the joint have been brought nearer to each other and almost into contact;

c) Joints assembled with wedges which avoid drilling the web of the rail.

These types of joints have not been in use for a sufficiently long time for it to be possible to draw any definite conclusions at present, but the results are encouraging, and it is of the greatest in-

terest that their introduction should be continued, if possible simultaneously on all railway systems, so that indisputable conclusions may be obtained which will allow of improvement being made in the present joints.

4. — The number of fractures of fish-plates is small, and the breakage of fish-plates is not generally of such nature as to endanger the running of the trains. It would appear desirable, nevertheless, that the strength of the joints should be increased :

a) By requiring, in the specification for the manufacture of fish-plates, the use of sound metal free from piping, excessive segregation, and any other defects;

b) By subjecting the fish-plates after manufacture to a suitable heat-treatment with a view to eliminating abnormal brittleness which they might possess.

5. — In order that the wear which is inevitably produced between the joints and the portions in contact may be localised as much as possible on the fish-plate which is easy to replace, it appears advisable that the fish-plates should be made of a softer steel than that used for the rails.

6. — With a view to diminishing the relatively heavy expenditure that would be occasioned by the scrapping of worn fish-plates, it would appear desirable to carry out the reconditioning of these fish-plates by restamping them hot so as to give them the original section or a rather heavier section to counterbalance the wear to which the bearing surfaces of the rails, with which they will be again used, have been subjected.

IV. — SUMMARY OF THE REPORT BY Mr. J. WILLEM.

(OTHER COUNTRIES.)

1. — The type of fish-joint most in use in the suspended joint, consisting of two angle fish-plates, assembled to the rails by means of four bolts; the horizontal flanges of these fish-plates bear upon the sleepers on each side of the joint and allow for the insertion of the screw spikes through the notches made in them. The rail joints are generally opposite to each other (not staggered) and the normal lengths of the rails are 12 m., 15 m. or 18 m. (39 ft. 4 1/2 in., 49 ft. 2 1/2 in. and 59 feet).

The railway systems unanimously appreciate the necessity for preventing the creeping of rails, and the advantage of adopting an arrangement independent of the joint with this object, but many of them have not commenced work on the subject for economic reasons.

2. — The present types of joints form weak points in the track, and the engineer should pursue his researches with a view to their improvement. Various new arrangements have been designed with this object : placing the joint sleepers nearer together, and even touching each other; the use of flat fish-plates of heavy section, etc., but none of these arrangements have yet been subjected to thorough trial.

No railway system has made extensive use of joints of which the tightening is effected by wedges or keys instead of bolts. It would appear, however, to be certain that the discovery of a suitable fishing system that avoids the drilling of the rails and all the disadvantages that result therefrom, would be a considerable improvement, and it would be of

interest for the technical staffs to make a serious effort in research of this kind.

3. — The use of metallic packing slips inserted between the bearing surfaces of the fish-joints to take up the wear of the bearing surfaces is the remedy that is most generally adopted. It appears, however, preferable to replace the worn fish-plates by others of larger dimensions than those of the normal fish-plate; re-pressing the fish-plates may give the same result, and it is certainly an economical method, but the re-pressing must be done with care.

4. — Nearly all the railway systems require heat-treatment in the manufacture of the fish-plates; some even require oil tempering in order to diminish the risk of fracture. This question of tempering is of interest, and should be studied by all the large railway systems.

5. — The high cost of material for the track makes the scrapping of worn or damaged parts a heavy expense, and will certainly lead the railway systems to take very serious steps towards the reconditioning of this material, and consequently the installation of special workshops equipped specially for carrying out this work.

GENERAL SUMMARY.

The findings and recommendations relating to the question may be summarised as follows :

1° Joints as presently constructed form the weakest part of the track and there is scope for improvement in the design, always bearing in mind that they should be composed of few pieces, be as simple as possible, cheap to instal and economical to maintain.

2° It would be advantageous to carry out *on all administrations simultaneously* tests of a certain number of joints which would appear to give better results particularly :

a) Bridge joints, in which the ends of the rails rest on a metal bridging piece between the sleepers on each side of the joint;

b) Suspended joints, in which the sleepers on each side of the joint are brought close to each other;

c) Joints in which holes in the web of the rail are not required.

3° The attention of engineers is directed to the very great interest which would attach to the design of a joint in which the holes in the web of the rail are not required and which would tend to eliminate a considerable proportion of the most frequent form of rail breakage.

4° Means for stopping creep of rails should be provided independently of the joints.

5° The standard length of rails should be increased as far as possible so as to reduce the number of joints.

6° The annual lubrication of fish-plates is to be recommended. The parts should be removed so as to facilitate the examination of the end of the rail covered by the plates.

7° It is important to use, in the manufacture of fishplates, metal free from segregation and other defects.

8° The heat treatment of fish-plates is to be recommended. Any abnormal hardness which may have been produced in the plates is thereby removed.

9° The re-forming of the fish-plates by re-forging when hot may be recommended for the sake of economy.

[656. 212.5]

QUESTION III

(Shunting yards) (1),

By W. SIMON-THOMAS, special reporter.

The four reports that have been presented on question III : *Shunting and marshalling yards for goods trains; Lay-out and organisation* (2), give particulars of extreme interest on the shunting operations in all countries of the world. These reports show that there are few problems more important to railway working and requiring more investigation on the part of the traffic service, than the question of better arrangements and better organisation of the stations at which goods trains are made up.

The greater the density of the traffic on railways has become, the better has it been recognised that shunting yards have a preponderating and increasing influence on the safety of the service and on economy of working. The enormous expenditure involved in the shunting operations requires reduction in the cost of this branch of the traffic service. Hence it is necessary to concentrate the shunting operations in a small number of shunting yards carefully selected with respect to the streams of traffic.

It is necessary that these stations should be so constructed that their output may amount to 5 000 or 6 000 wagons per 24 hours in each direction, in order that as many through and semi-through trains as possible can be made up. Nevertheless, old goods yards that involve very costly working are to be found in every country. It must not, however, be forgotten that the creation of a new shunting yard will in some cases be more economical than the extension under bad conditions of an existing shunting yard that is not well laid out.

The arrangement of the yard with regard to the main lines is most generally parallel to the railway, and to one side of the main lines, and this arrangement is considered the most suitable.

Whereas the gravity method of shunting which has been adopted in many shunting yards of considerable size should be noted, the construction of level yards with humps is more common than that of yards on a continuous gradient. The latter form of construction depends mainly on the existence of a natural slope. Some Administrations, however, are considering the inclined construction of some portions of the yard and particularly of the groups of sidings for receiving the trains and for classifying the wagons according to destination.

Although the construction of yards for traffic in both directions is frequently adopted, those arranged for traffic in one direction are more common. As it appears to increase the capacity of the sidings considerably, the arrangement of one-direction traffic should be considered as that of the future, because of its lower cost for performing shunting operations.

In some yards, the arrival tracks run by fly-over roads over or under the main lines; this is certainly the best method. The need for this form of construction, however, depends in the first instance on the density of traffic on the line. In order to avoid the disadvantage of the one entrance to the arrival tracks being in the opposite di-

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(1) Translated from te French.

(2) See *Bulletin of the International Railway Congress Association*, February 1925, p. 237; October 1924, p. 793, and May (1st part) 1925, p. 1619; November 1924, p. 877; May (1st part) 1925, p. 1495.

rection to the junction, in those yards having one direction traffic, it is possible to construct loops at the entrance to the shunting yard; this arrangement is specially desirable in yards in which the arrival tracks are arranged for gravity working.

The figures that have been published in the reports show that the usual practice is to construct at least three groups of sidings : the reception sidings, the sorting sidings, and the departure sidings. In yards in which a large number of stopping trains have to be made up according to destination, there are also groups of sidings for special marshalling.

The essential factor that enables the length of the reception tracks to be determined, as well as those of sorting and departure, is the maximum length of the goods trains, a length that varies in different countries. The number of reception and departure tracks depends on the magnitude of traffic to be handled, whereas the number of sorting tracks depends on the instructions relating to the make-up of the trains.

The output of a shunting yard, however, is limited in the first instance by the capacity of the sidings. The necessity for obtaining the maximum output is particularly felt at those stations in which the daily traffic is very great. But even though the number of wagons requiring to be handled every 24 hours should not be large, it is nevertheless of much importance that a convenient layout should be made at the hump or the gradient leading to the sorting sidings, in order that it may be possible to carry on the work economically during the rush hours, when many wagons require to be handled.

The detailed investigations made regarding the various resistances which affect the running of the wagons, during the last few years have made it possible to calculate exactly the gradient required for the sorting sidings. From these also can be found the necessary height and the inclination to be given at the hump, in order that wagons may arrive at the foot of the gradient at a sufficient speed, and may be sufficiently far apart from each other. It may, however, happen that the steep gradient and total height of the hump that must be calculated to provide against unfavourable atmospheric conditions, may prove too great under more favourable conditions. In this case, the speed of free-running wagons may become too great to allow of their being stopped by means of shoe brakes on the rails of the sorting sidings. It follows that economic arrangement of the sidings depends greatly on adequate braking methods. Hence the solution of the problem of practical and reliable methods for slowing the wagons is of paramount importance.

Up to the present time, we have been content, on the Continent, with the slipper brake on the rail and its application to the roller form of brake largely used in France in 1924; in England, the lever brake fitted generally on both sides of the wagons is used, and require running shunters; in America, the country of wagons of large tonnage, each wagon is accompanied by a brakesman.

At the present time we have available an automatic checking brake with counterweights which shows important possibilities from the point of view of safety in service and economy in working.

An appliance of this kind is already in use in Holland, in Susteren station; in Denmark, in Aarhus station; and in some German stations.

Apart from obtaining automatic working of the sidings, the organisation of the preliminary operations and the signalling methods adopted are also of great importance. With regard to signalling methods, semaphores, luminous signals, and audible signals are all used. The variety of systems shows the interest given to the subject by the various Administrations.

The arrangement of the head of the group of sorting sidings is an essential

feature. We are already agreed as to the necessity for making the danger zone as short as possible. The control of the whole of the points, centralised in one cabin, appears generally to be the best. The automatic electric installation, for operating the points, appears to be that of the future.

All the reports have mentioned the great importance of affording communication between the various sections of the yard. It is necessary that these should be sufficient in number, and that their arrangement, particularly with regard to the locomotive shed should be decided with the greatest care in order to avoid stoppages during the shunting operation.

With regard to other installations, it is of interest to note that in America the weighbridge is generally arranged on the down grade leading to the sorting sidings, whereas in Europe the arrangement alongside the hump is most usual.

From the statistics giving the results of working, we think that it can be stated that it is of increasing interest to obtain exact figures for the cost of the shunting operations.

Moreover, the question of shunting yards of such large size has provided a great mass of data which should serve as a basis for your discussion.

SUMMARY

1. — A shunting and marshalling yard, well placed with regard to the railway system, enables traffic to be conducted more rapidly, and increases the traffic capacity of the lines.

The arrangement depends on the organisation of traffic into through, semi-through, and stopping trains, as required by the magnitude and distribution of the traffic.

These yards are placed at centres in which the traffic is sufficiently dense to necessitate distribution over the different routes.

2. — They comprise in general a group of reception or arrival sidings, a group of sorting sidings, and very frequently groups of sidings for making up according to destination, of sidings for trains waiting for departure, and of tranship sheds.

Finally, the installation is completed by a disinfecting yard, a wagon repair section, and a locomotive shed.

The length of a station of this kind may amount to from 3 to 5 km. (1.8 to 3.1 miles).

3. — The use of gravitation for shunting may be adopted in shunting yards by constructing these on a continuous gradient or on the level with humps. The first method is only to be recommended in case a natural gradient exists, and the number of wagons to be shunted does not exceed 5 000 per day.

An arrangement of shunting yard in which the formation is partially inclined, may have advantages, particularly in the case of groups of reception sidings and sidings for sorting according to geographical destination.

But in such case, it is advisable to be able to perform the operations by means of locomotives in times when the atmospheric conditions are unfavourable and the working of the group of sidings by gravity is not satisfactory.

4. — A group of shunting sidings for each direction is necessary if the number of wagons to be shunted per day exceeds the capacity of a single hump. Otherwise, a single group of sidings is to be recommended for both directions of traffic, unless each direction of traffic is practically independent of the other.

In yards, however, that are arranged with a single group of shunting sidings, it is necessary to make provision so that the yard can be enlarged with groups of sidings for both directions of traffic when the traffic has increased.

5. — It is necessary that the number

of reception tracks should be such as to be able to receive the trains as they arrive, and consequently to avoid blocking up the main lines, and it is also necessary to provide for simultaneous entrance of trains coming on different lines.

The length of the reception lines should be sufficient to take the longest trains; the most practical arrangement consists in placing these lines immediately before the hump.

6. — The preliminary operations for splitting up the trains, which vary according to the arrangement of the yard and the traffic to be handled, should be carefully arranged so as to occupy the shortest time possible. This condition becomes most essential in winter, owing to the increased rolling resistance arising from the cooling of the oil in the axle boxes.

7. — During the operation of splitting up the train, the indication of the particular sidings given to the pointsman should be done in a simple and clear manner, equally capable of being worked by day, by night, and during fog.

Apart from the method using shunting tickets, an arrangement with electric push buttons at the hump, and an electric board in the cabin, appears to be the most practical.

8. — Communication between the driver of the shunting locomotive and the foreman shunter and the pointsman should be such that the orders given by the shunter can be carried out immediately by the driver.

The installation of an electric bell in the cab of the locomotive appears to be the simplest and most practical solution.

9. — It is necessary to design the hump or the grade at the splitting-up sidings as accurately as possible, taking account of the various resistances that affect the running of the wagons as they come over.

The influence of the wind resistance being considerable, the splitting-up sidings should be arranged in the most favourable direction in relation to the prevalent winds.

10. — The radius of curvature of the top of the hump in vertical section should be at least 200 m. (10 chains).

11. — The hump should be of adequate height for giving sufficient speed to all wagons to enable them to reach any point on the shunting sidings, even when the atmospheric conditions are unfavourable. This speed should be such that the wagons are spaced sufficiently far apart on reaching the foot of the steep gradient of the hump.

To obtain this speed, it is necessary that the total height of the hump should consist, as far as possible, of only a single steep gradient.

The speed of the wagons should be reduced by means of a rail-brake. The automatic rail-brake with counterweight, in which the action is exerted by four brake-rails arranged on both sides of the track-rails, is preferable to any other methods.

12. — The construction of a hump with two arrival tracks at different levels is only necessary when the difference between favourable and unfavourable atmospheric conditions is such that a hump constructed for the most unfavourable conditions does not allow of the wagons being stopped effectively under the most favourable conditions.

13. — At humps arranged with a single arrival track, a track adjacent to the hump, constructed on the level, has the advantage that it can be used for shunting by hitting up at times of violent atmospheric disturbance.

This road may also be used with advantage as a road on which the auxiliary locomotive used for pushing up the wagons on the shunting siding, may stand.

14. — The head of the group of shunting sidings should be arranged as near as possible to the top of the hump or the first pair of points.

The minimum distance between the

top of the hump and the first pair of points should be 15 m. (50 feet).

It is necessary that the head of the group of sidings should be so arranged that the tracks do not give too great differences of resistance in relation to one another, and that the distance from the foot of the gradient to the fouling point should be as short as possible, and nearly the same for all the tracks.

If necessary, the head of the group of sidings may be constructed on a plane of sufficient inclination to overcome the resistances due to the curves and reverse curves.

15. — The number of tracks in the shunting sidings depends on the traffic to be handled, and on the instructions relating to the make-up of the goods trains. In determining this number, account must be taken of the maximum possible; that is, 35 to 40 for level yards with humps. The fact that the addition of sidings for some supplementary routes may appreciably facilitate the make-up of semi-through trains must not be overlooked.

The effective length of the shunting sidings depends on the length adopted for the through trains, with the addition of a certain length corresponding to the distance necessary for stopping the last wagons.

In yards arranged on a continuous gradient it is necessary that the slope of the shunting sidings should be from 5 to 7 per mil in order that the batches of wagons may be set running under the action of gravity alone.

16. — In yards arranged on the level, departure direct from the shunting sidings is advisable, unless the density of traffic requires the transfer of trains to groups of departure sidings immediately after marshalling.

17. — The number of connecting tracks between the shunting sidings, sorting, and departure sidings, as well as the number of groups of sorting sidings necessary for easy working, depends on the number of trains to be made up, and on the instructions relating to their make-up.

18. — In yards constructed on a continuous gradient, the groups of sorting sidings follow the group of shunting sidings. In yards on the level, with humps, the most practical arrangement of the sorting sidings is alongside the shunting sidings or between the ends of the tracks of this group.

19 — An arrangement of the group of sorting sidings on a down gradient has advantages, and increases the output of the yard.

20. — The number of tracks in a group of sorting sidings, generally from 12 to 14, depends on the instructions relating to the make-up of those trains that comprise the greatest number of destinations. An effective length of 200 m. (220 yards) is sufficient for these tracks; a group of sidings with access at both ends is preferable to a group of dead-end sidings.

21. — In yards constructed on a continuous gradient, it is necessary to arrange a small group of correction sidings placed between the sorting group and the departure group of sidings. A group of this kind appears to be equally desirable at the end of a sorting group of sidings having a down grade.

22. — The use of strong and new material for the construction of groups of shunting and sorting sidings is essential.

23. — The groups of departure sidings should serve as standing room for the trains that have been made up and are awaiting the time for their departure. They should also exercise a regulating function in case of disturbance of traffic on the main lines.

The number of departure tracks depends on these two functions, and account must be taken of the possibility of trains leaving the shunting sidings direct.

24. — If the goods trains are fitted with an automatic compressed air brake, the departure tracks should be provided with a supply pipe connecting to a compressor to allow the air brakes to be tried on all wagons before the train leaves the station. If any of the sorting sidings serve also as departure sidings they should be similarly equipped.

25. — In yards which have to provide for through trains and semi-through trains overtaking others, it is necessary that groups of lie-by sidings specially reserved for this object should be provided.

The most rational arrangement for the tracks with a view to the uncoupling of batches of wagons, is alongside the group of arrival sidings.

26. — The number and arrangement of the roads that afford communication between the various portions of the yard are of very great importance. To avoid level crossings, tracks arranged for the independent running of the locomotives may be constructed with a maximum gradient of 1 in 30.

27. — A small group of sidings specially intended for front vans is to be recommended. It should be so arranged that the vans can be easily uncoupled and removed by the main line locomotives.

28. — In large shunting yards, small coal stages, with water cranes for filling up the shunting locomotives, arranged near the places in which these locomotives usually work, are advantageous.

29. — The weighbridge should be so arranged that the wagons running over it may again be pushed direct over the splitting-up sidings.

30. — The construction of repair shops for rolling stock near the shunting yard, having regard to the situation of the shunting yard relatively to the rest of the railway system, may be of advantage.

31. — In most cases, the traffic organisation, particularly at large junctions, requires the addition of transhipment installations at shunting yards. In yards with a single group of shunting sidings, the most rational position is obtained by lengthening the group of shunting sidings. In yards having separate shunting sidings for each of the two directions of circulation of traffic, the most practical site for the transhipment installation is in the centre of the yard.

32. — Transhipment is effected in most of the yards by means of hand trolleys. It is only in yards in which the transhipment installations are very large, or in those comprising warehouses with several parallel platforms, that handling by means of tractors and electric runabouts may have advantages.

33. — The arrangement of the locomotive shed and the organisation of its supplies are of great importance. It is necessary that the connections between the locomotive shed and other parts of the yard should be conveniently arranged and sufficient in number.

These installations should be arranged on a carefully thought-out scheme, taking account of the technical requirements of the supplies. It is necessary for the operations of supplying the locomotives with coal, sand, and water to be effected rapidly and in proper order.

34. — Heavy traffic requires a staff of employees for whom it may not always be possible to find local housing accommodation. It may be desirable in this case that the Administration of the railway system should construct houses or barracks and even canteens close to the station.

35. — From the point of view of economy, it is necessary to keep a careful check, based on daily records and statistics under definite heads, on the working of the shunting sidings.

SECTION II. — LOCOMOTIVES AND ROLLING STOCK.

[621 .133 & 621 .137.1]

QUESTION IV-A

(Reduction of the cost of traction : Fuel and its Combustion).

By G. H. EMERSON, special reporter.

Mr. EMERSON'S REPORT (1).

(The report covers North and South America with particular attention to the United States.)

Choice of fuel. — Locomotive fuel is usually chosen on the basis of *a*) availability in adequate quantity and *b*) total cost per unit of traction produced. On these grounds bituminous coal is the generally used locomotive fuel being widely distributed and marketed at lowest cost. Practically the sole exception is fuel oil produced in ample quantity in a few parts of the country remote from producing coal measures.

The abundance of high rank coal and the comparatively favorable cost of its production and distribution have forestalled the production and use of processed fuel, briquettes, peat, lignite or the mixing of coals.

Pulverized fuel has not been found practical for locomotive use because of limited combustion space available in the locomotive firebox of conventional design.

Oil fuel is used by several roads located in or adjacent to the mid-continent, Texas and Southern California oil fields which are remote from any extensive coal measures. There are many advantages resulting from the use of oil fuel where the comparative cost of the fuel permits, among which may be emphasized the reduced consumption of stand-by or terminal fuel, lower labor cost of hostling, easier control in firing to avoid waste, and greater convenience of storing and disbursing to locomotives.

Colloidal fuel is still in the experimental stage.

Apparatus for combustion of solid fuels.

Grates. — The practice of using cross rocking grates (axis extending across firebox) is practically universal in North America. A small number of roads use all finger grates and a few all table grates but it is usual that some locomotives, the older designs, are equipped with finger grates and some, the modern designs with table grates. Locomotives equipped with mechanical stokers are usually equipped with table grates.

The common practice is to design the

(1) See *Bulletin of the International Railway Congress Association*, November 1924, p. 1029.

rocking grates to permit dumping of individual grate bars. In a small percentage of modern locomotives, and in a greater proportion of the older designs drop grates at front or back of the firebox are provided.

Special mixtures of grate bar iron are not in general use.

In recent designs of grates the air opening approximates 45 % of grate area.

Oil burners. — Atomizers employing steam are used to the practical exclusion of mechanical atomization. The external atomizer principal is in most general use. The preferred location for the burner is at the front of the draft pan, with open furnace, low brick work and maximum exposure of heating surface.

Indirect oil heaters are usually employed.

Mechanical stokers. — The mechanical stoker is used on locomotives of greater tractive capacity than about 50 000 lb. which are considered to be of a capacity greater than can be developed consistently by hand firing. 4 000 lb. of coal per hour for limited periods is considered the practical limit, for hand firing. There are about 8 000 mechanical stokers in use in North America.

Smoke consumption. — The factors in the reduction of the visible products of combustion in the order of relative importance are design and maintenance of the locomotive, character and grade of fuel, operation of the locomotives by engineers and firemen, appliances such as brick arches for promoting good combustion and appliances such as steam and air jets for promoting combustion and modifying the appearance of the emission from the stack.

Spark arresters. — There are no departures of consequence from the conventional design of locomotive front end with netting arranged to break up the large sparks.

Mr. COLLETT'S REPORT [1].

(The report covers British Empire Railways).

Choice of fuel. — Reports from 21 railways indicates the use of coal fuel. Two colonial railways include oil fuel over certain sections of their lines, purchase of fuel is usually by contracts over a period of 3 to 12 months, and stocks are carried by stacking in the open about three months supply at the various depots. Coal is selected on the basis of the requirements of the various classes of service from the nearest supply taking into consideration comparative cost delivered and the calorific value obtained. Specified quality is maintained by inspection at Collieries and at consuming points checked by standardized tests on locomotives in service where necessary. Coal testing plants are not generally used. The clinkering of lower quality coal which is practically unavoidable is decreased by mixing this class of fuel with a better quality. With the average coal selected for locomotive purposes clinkering is not experienced to any serious extent.

Oil fuel is used to a very limited extent. The total running costs are generally

(1) See *Bulletin of the International Railway Congress Association*, March 1925. p. 797.

considered greater than for coal depending upon the fluctuation of oil prices, especially in the British Isles. Owing to the long distance from coal supplies, oil fuel is used on one section of the North Western Railway of India. The fireboxes are designed for coal burning and modified for the use of oil fuel. Front end burners are used in long narrow fireboxes. On wide fireboxes, back end burners are used with brick arches.

Pulverized and colloidal fuels have only been used experimentally. Neither is a commercial proposition when compared with coal at prevailing prices. The deposit in the smoke-box with pulverized fuel approximates 7 % with an equal quantity emitted from chimney in a semi-burnt condition.

Briquettes have only been used during periods of labor trouble causing shortage in coal supply.

Apparatus for combustion of solid fuels.

Grates. — Cast iron, sand cast in preference to chill cast, is in general use for fire bars. Ratio of air space to grate area varies from 33 % to 50 %. Rocking grates are reported to be essential in the successful use of coals of high ash content. Fire grates fitted with dumping devices reduce the time required for fire cleaning 20 % to 60 %.

Mechanical stokers. — Mechanical stokers have been limited in their application to Colonial Railways, where they have been used on account of the locomotives becoming too large for their full capacity to be maintained by hand firing. The fuel consumption per unit of power developed is approximately the same with hand or stoker firing, the same grade of fuel being used. Engines having a rated tractive effort of 50 000 lb. or over in freight service and 50 000 lb. in passenger service justify the use of mechanical stokers.

Smoke consumption. — To insure correct combustion and therefore smoke prevention the provision of an adequate air duct through the fire doors when closed is considered necessary. Openings vary from fixed minimum of 8 % of fire hole area to averages of 16 % and some adjustable type provide up to 30 %. Some use is made of curved deflector plates and fire doors arranged to open inwards and thus function in a similar manner to the deflector plate.

In certain cities having smoke laws, only low volatile coals are used. In suppressing smoke while building fresh fires reliance is generally placed upon the judicious use of the steam blower.

Spark arresters. — Several companies have adopted spark arresters in the smoke box that do not impede the draught. The use of chimney top spark arresters is confined to certain localities. In general the plates are arranged for the dual function of spark arresting and draught deflecting by inducing the flue gases to pass more freely through the bottom section of tubes. The effect of well designed spark arresters, is to equalize the smoke box vacuum at top and bottom rows of tubes, and has resulted in improved steaming and combustion.

[625 .135.2 & 625 .214

QUESTION IV-B

(Reduction of the cost of traction. Lubrication of axle-boxes for all rolling stock),

By Sir HENRY FOWLER, special reporter.

INTRODUCTORY REMARKS.

The reports upon which the following information is based are as follows :

Report No. 1 for America, by Mr. G. H. Emerson (1);

Report No. 2 for all countries, except America and the British Empire, by Mr. Tete (2);

Report No. 3 for the British Empire by the present writer (3).

The field covered by these reports may be divided into three main categories, *viz.*, design, maintenance, and the nature of the lubricants used. It is obvious that the question of the design and maintenance of axle-boxes is largely a matter of close attention to various small details, the broad principles which are quite simple and straightforward, being much the same in all cases, while the merit or demerit of any particular type lies in the amount of care which the designer has exercised in providing for the numerous and almost trivial conditions which may arise in practice. Thus it is difficult in the time at our disposal to give a brief and concise account of a subject which is so largely a matter of detail.

In the following it is proposed to deal first with axle-boxes for locomotives and tenders, and subsequently with axle-boxes for coaching and wagon stock.

Axle-boxes. — Locomotives.

The most widely used material for engine axle-boxes is cast steel, although forged steel is also used. Outside America non-ferrous alloys are in some cases used, a separate brass not being then required. For tender axle-boxes cast iron is also used.

Dust shields are in most cases fitted to tender and bogie wheels, but very few axle-boxes for coupled wheels are so provided. This is doubtless due to the difficulty in doing so, but it appears desirable that these should be provided wherever possible.

The method of fitting the bearing to the journal differs but little on the various administrations. The care taken depends on the speed at which the engine has to work and the amount of breaking-in which is allowed before using on normal service.

The pressure allowed per square inch of projective area varies widely, but it would appear that in Europe pressures of 300 lb. per square inch are usual for coupled axle-boxes, while in America they are somewhat less. It would appear

(1) See *Bulletin of the International Railway Congress Association*, November 1924, p. 1055.

(2) See *Bulletin of the International Railway Congress Association*, April 1925, p. 859.

(3) See *Bulletin of the International Railway Congress Association*, February 1925, p. 313.

very desirable to keep down the bearing pressure as much as possible, both as regards reducing wear and the liability to run hot.

It is almost universal practice to white metal axle-box brasses, except in America, where the axle-box brasses for coupled wheels are as a rule without white metal. The arrangement of the pockets for the white metal differs widely.

There is also considerable variation in the composition of the white metals used. In America this is usually a lead base alloy, while elsewhere tin base alloys are somewhat in the majority.

The composition of white metal that will give satisfactory results depends largely on the method by which it is applied, on the pressure per square inch, on the lubrication, and the nature of the service performed. It would appear that where the bearing is subjected to shock or hammering action a tin base alloy is preferable. For tender or carrying axle-boxes in which only a rolling action is entailed a lead base alloy should prove satisfactory.

Mechanical lubrication is hardly out of the experimental stage, although results have been encouraging, and its application appears to be extending.

Only one administration reports having fitted ball or roller bearings to the carrying and tender wheels. In no case do these appear to have been fitted to coupled wheels, where their application would present difficulty.

In the majority of cases, mineral oil is used without any addition, although on some administrations, especially those in the British Empire, a small proportion of vegetable or animal oil is added. Advantage might be taken of the recent investigations on the improvements which occur when a small percentage of a fatty acid is added to a mineral lubricant.

The usual class of lubricant used in America for coupled-wheeled axle-boxes is a solid cake of grease, which is pressed against the underside of the journal by means of a spring; a perforated metal plate being placed between the cake of grease and the journal.

Axle-boxes.
Coaching and wagon stock.

Cast steel appears to be the most widely used material, except in the British Isles, where cast iron boxes are general. It would appear that the former material is advisable for modern stock, especially where vehicles are liable to rough usage.

In the countries dealt with by all three reports the open fronted type of axle-box appears to be the most widely used. In Europe and the British Isles a certain number of axle-boxes are of the divided type. This latter arrangement facilitates an examination of the journal, but in view of the possibility of the fastenings working loose and allowing oil to escape it would appear that the open fronted type, in which the body of the box is in one piece, is the most satisfactory. In any case it is important to guard against loss of oil and the possibility of rain water entering the axle-box, while allowing facilities for inspecting the journal and the pads or packing. It is also advisable to provide a distance piece or glut between the brass and the top of the box so as to facilitate the renewal of the brass.

Dust shields are invariably fitted, but some of the types used, although simple, appear somewhat inefficient and capable of improvement.

The remarks given above on the method of fitting locomotive bearings to the journal also apply to coaching stock and wagons.

The pressure allowed per square inch of the projected area of the bearing varies considerably, but 500 lb. per square inch appears a usual figure in all the countries concerned, although in some cases this is considerably exceeded.

The angle included at the centre of the journal by the arc of contact varies widely. So far as bearing area is concerned, an angle of 60° appears sufficient, but a deeper bearing may be advisable to guard against the liability of the brass being knocked off the journal by rough shunting. For this reason where a shallow bearing is used the brass should be provided with side lugs which extend downwards without normally coming into contact with the journal.

White metal is universally used for axle-box bearings, except on certain narrow gauge stock, and in obsolescent grease lubricated axle-boxes in use on a few British railways. Lead base alloys are in the majority.

Oil lubrication appears to be universal for all up to date stock. In America the practice is to use packing consisting of a mixture of wool and cotton waste. In the British Empire the practice is divided between the use of packing and of pads, whilst in the countries dealt with in Report No. 2, pads appear to be generally used.

Roller or ball bearings have been experimented with by administrations in the countries dealt with in all three reports. One administration has had considerable experience extending over some years with both passenger and freight stock. A reduction in fuel consumption is recorded, whilst the bearings have proved satisfactory as regards maintenance. On another administration tests between two similar passenger trains, one fitted with plain bearings and the other with roller bearings, showed that although there was a reduction in resistance at starting, this disappeared after running a short distance, and there was no saving in fuel. The first cost of these bearings is high, and sufficiently long experience has not yet been obtained to determine the relative cost of maintaining these bearings. It would appear that the type of stock for which they are most suitable is that used for suburban services where frequent stops are made.

The great majority of administrations use mineral oil without the addition of any vegetable oils. In any case the latter is only a small proportion. Whether the composition of the oil is varied in accordance with the season depends mainly on the climatic conditions of the countries concerned.

It is usual practice in the countries covered by Reports Nos. 1 and 2 to recover waste oil taken from axle-boxes. Only a few of the administrations dealt with in Report No. 3 have any system of refining this oil and again using it for axle-box lubrication. Others use it, as it is, for unimportant purposes in the workshops.

Speaking generally of the question of coaching stock and wagon axle-boxes, and especially as regards the latter, owing to the fact that they may have to run over lines owned by different administrations or over different divisions of the same administration, it is very desirable that standardised types should be adopted, so that repairs may be readily carried out at any repairing depot, and in order that the stock of spare parts may be kept down without the risk of holding vehicles out of traffic whilst special parts are obtained. Furthermore, with a standardised type the examiners, oilers and fitters become accustomed to the design, and are able to do their work more expeditiously.

SUMMARY.

Axleboxes. — Locomotives.

1. — Cast steel is the most widely used material for engine axle-boxes. The use of non-ferrous alloys by a few administrations may be referred to.

2. — Dust shields should be fitted whenever possible.

3. — It is advisable to keep down the bearing pressure as far as possible in order to reduce wear and avoid hot

bearings. It would seem that a close study of this point would be useful, although in some cases it is governed by factors of design not pertinent to this question.

4. — The most suitable class of white metal depends upon the conditions under which it is used. Generally speaking a tin base alloy is more suitable when an alternating or hammering action has to be sustained, but a lead base should be suitable for other cases.

5. — Mechanical lubrication, though still in an experimental stage on the majority of administrations which have adopted it, is giving encouraging results, and its application is extending.

6. — No administration reports the fitting of ball or roller bearings to axle-boxes of coupled wheels.

7. — Mineral oil is almost universally used, a certain number of administrations adding a small proportion of animal or vegetable oil. In America grease lubrication is general for coupled axle-boxes.

Axle-boxes.
Coaching and wagon stock.

1. — Cast steel appears to be the best material for modern high capacity stock, especially where subjected to rough usage.

2. — The open fronted or « one piece » body type of axle-box is the most widely used.

3. — Careful attention should be given to guard against loss of oil from, or rain water entering the axle-box. Dust shields in some cases appear capable of improvement.

4. — It is desirable that the pressure on the bearings should be kept within moderate limits, in order to lessen wear and reduce the liability to run hot.

5. — White metals having a lead base are the most widely used, and there seems no reason why they should not be universal.

6. — Oil lubrication is universal for up to date stock. Practice is divided between the use of pads and packing. Either method appears satisfactory if proper attention is given to design and maintenance.

7. — Roller and ball bearings have been experimented with by several administrations. Information is somewhat limited and not entirely in agreement. Experience not sufficiently long to determine depreciation and upkeep. The first cost of fitting is high. It would appear that these bearings are best adapted for use on suburban vehicles, as they give a lower frictional resistance in starting.

8. — Majority of administrations use mineral oil without any addition of animal or vegetable oil.

9. — It is fairly general practice to recover and refine waste oil recovered from axle-boxes or from discarded packing or pads.

10. — It is very desirable, especially as regards wagon stock, that standardised types of axle-boxes be adopted so as to reduce the necessary stock of spares, and in order that the examining and repair staff may become accustomed to the design and carry out their work more expeditiously.

[621 .335]

QUESTION V

(High speed electric locomotives),

By M. WEISS, special reporter (1).

Summary and findings on Reports Nos. 1 and 2 on the question of electric locomotives (2).

The summary of the questions treated in each of the reports has enabled the following findings to be obtained :

1. — There are only relatively few electric high-speed electric locomotives (running at speeds above 75 km. — 46.4 miles — per hour) in service or at present being constructed. These locomotives run on or are intended for the following railway systems :

America :

Chicago, Milwaukee & St. Paul (Ch., M. & St. P.);
New York, New Haven & Hartford (N. Y., N. H. & H.);
New York Central (N. Y. C.);
Chilean (F. F. C.);
Paulista (C. P.);
Pennsylvania Railroad (P. R.).

Germany :

German State Railways (D. R. B.).

Austria :

Austrian Federal Railways (B. B. Oe.).

England :

Metropolitan Railway.

France :

French Midi Railway (Midi);
Paris, Lyons & Mediterranean Railway (P.-L.-M.);
Paris Orleans Railway (P.-O.);

— The two last are in process of electrification.

Italy :

Italian State Railways (F. S.).

Sweden :

Swedish State Railways (S. I.).

Switzerland :

Swiss Federal Railways (C. F. F.).

2. — We have only been informed of high-speed locomotives without carrying axles operating on the Metropolitan Railway, the P. O., and the N. Y. C.; the two latter administrations have also locomotives with carrying axles and bogies.

3. — The transmission of the tractive effort from the motors to the driving wheels is effected by very varying methods. The following are to be noted :

a) *Direct drive by connecting rods* on the P. L. M. on the trial 2B1+1B2 locomotive of the Auvert system, on the P. O. in the 2BB2 locomotive of the Ganz system, on the F. S. on all the electric locomotives, on the S. I. on the 2B2 type locomotives, on the D. R. B. on several

(1) Translated from the French.

(2) Vide *Bulletin of the International Railway Congress Association*, numbers for January 1925, p. 179 and April 1925, p. 1019.

types of locomotives, and also on the P. R. on locomotives of the 2BB2 type.

b) *Drive through gearing and coupling rods* : on the S. I. (types 2B+B2 and ICI); on the C. F. F. (type 2C1); on the B. B. Oe. (type 1C1); and on the P. R. (type 1D1).

Direct drive is used in the following forms :

c) « *Gearless* » *type* on the P. O. (trial locomotive of the General Electric Company type 2C+C2); on the Ch., M. & St. P. (1B+D+D+B1), and on the N. Y. C. (type 2D2 and B—B+B—B).

d) *Tramway type of drive* : on the Metropolitan Railway (type B—B); on the P. O. (type B—B); and on the P. L. M. (type 1C+C1).

e) *By the Westinghouse system :* with hollow shafts and drive through springs: on the P. L. M. (type 2B—B2 on one half of the locomotive); on the C. F. F. (type 1C1); on the Ch., M. & St. P. (type 2C1 +1C2); on the N. Y., N. H. & H. (type 1B+B1 and 1C1+1C1); on the C. P. (type 2B+B2 and 1B+B1).

f) *Various systems* : Brown, Boveri & Co. of Baden (Switzerland) (Buchli system) on the P. O. (type 2—D—2); on the C. F. F. (type 2C1 and type 1B1+1B1 on one half of the locomotive).

M. F. O. system : on the P. L. M. (type 2B—B2).

P. L. M. system : on the P. L. M. (type 2B—B2 on one half of the locomotive).

Tschanz system : on the C. F. F. (type 1B1+1B1 on one half of the locomotive).

g) *Vertical motor system :* on the Midi (type 2C2), and on the B. B. Oe. (type 1D1).

4. — The locomotives with connecting-rod drives have the advantage possessed also by steam locomotives, of having the centre of gravity higher than in the other types of locomotives, which is of importance for securing good running.

This arrangement, if well made and well maintained, provided that it is also fitted with spring driving gear, appears to give good results.

The rotating masses on electric locomotives can be accurately balanced so that there is no production, as in steam locomotives, of additional load due to hammer blow, hence it is possible to increase the axle loads (P. R.: type 1D1 locomotive 35 tons; C. F. F. : type 2C1 locomotive, 20 tons).

5. — The methods of drive given under 3.*f*) and 3.*g*) have the same advantages in respect to height of centre of gravity and axle load as are obtained with connecting-rod drives.

6. — With the Westinghouse drive, spring breakages frequently occur when the axle load is high (Ch., M. & St. P., 28.6 tons), and when concentricity of the driving axle and of the hollow axle cannot be accurately maintained in service, a fact that is particularly to be feared on locomotives having more than three driving axles on one frame.

7. — In locomotives of which the height of the centre of gravity is relatively low, and therefore causes greater stresses in the superstructure (due to lateral shock), it is advisable to reduce the axle load as much as possible (P. O. 12.4 tons; N. Y. C. 15 to 17 tons).

8. — In order to obtain good stability in running for high-speed locomotives, a long wheel-base should be provided.

9. — The leading wheels with lateral play (radial axleboxes) and leading bogies are generally fitted with restoring gear (springs or inclined surfaces). The restoring force varies greatly, from 0 kgr. (type 1C1 B. B. Oe.) to 6 700 kgr. (14 800 lb.) (type 1C1 of the C. F. F.) according to the various types of locomotives.

10. — The methods adopted for col-

lecting current are generally of the two following types :

a) Overhead collectors of the pantograph or bow forms, which are in general use on lines using single-phase current, and are also often used on lines worked by continuous current.

In the case of all the administrations, the collector is raised by compressed air, with the exception of the Midi Railway, on which it is lowered by this means. The contact pressure of the collectors on the wire varies from 10 to 15 kgr. (22 to 33 lb.) for continuous current, and from 3 to 5 kgr. (6.6 to 11 lb.) for alternating and three-phase current.

b) Collector shoes are only used on lines worked by continuous current.

11. — The main switch is either constructed with a magnetic blow-out, with or with-out high speed break (the latter process is coming more and more into use) for continuous current, or with a multiple-break oil break for alternating current.

The main switch is controlled differently on different administrations, either by hand, or by compressed air, or by electro-pneumatic control, or it is electro-magnetic, or electric.

12. — The control gear appears to be settling down into the two following main forms :

a) For continuous current and to some extent for single-phase current in the form of a controller with contactors;

b) For alternating current, either in the form of controllers with contactors as above or in the form of cylindrical contacts or analogous appliances to those used on the B. B. C. locomotives, which consist of contacts arranged near together, with special contacts for breaking the spark.

The control of these appliances has the same variations as that of the main switch, although it would appear that the electro-pneumatic control is in most general use up to the present.

13. — The transformers required on the single-phase locomotives, and to some extent also on the three-phase locomotives, are of the oil immersed type, or of the cooled air type.

Without wishing to enter into a discussion on the inherent advantages of one or other of these types of transformers, it may be said that the oil immersed type appears to be more favoured than the other.

The cooling of the transformer is generally effected by means of fans.

14. — The external form and the dimensions of the traction motors vary with each type of locomotive. Between the lowest powered locomotives of 185 to 275 H. P., of the Metropolitan Railway and the Midi, to the highest powers of 3 000 H. P. of the D. R. B., all intermediate powers may be found. The mean value is from 550 to 600 H. P.

The cooling of the motors is, with few exceptions, effected by special fans.

Where continuous current is used, the question of insulation generally presents some difficulty; with alternating current on the other hand, the weak point is in the commutator. Experience shows, however, that the cost of maintenance under some conditions can be considerably reduced, and the mileage run after turning up till this is again required may be high (150 000 km. — 94 000 miles — on the S. I.).

15. — The auxiliary electric equipment of the locomotives does not vary appreciably for different types of locomotive.

The question of train heating has not yet been definitely settled, but appears likely to be generally effected, in Europe at any rate, by means of electric resistances on the trains.

16. — We should here remark that direct comparison between the power of

these locomotives is rather difficult owing to the fact that at present there are no existing international standards that define the maximum permissible heating of the motors, and the methods by which the tests shall be carried out.

The weight in kilogrammes per horse-power at the tread of the wheel, as well as the power that can be developed for one hour, given in the comparative table for unit weight per H. P., can for this reason only be taken as approximate.

The interesting points to which we wish to draw special attention, and which we recommend particularly for discussion, are the following :

I. — Is either the tram type or the « gearless » type to be recommended for the drive of high-speed locomotives, and for what maximum speed?

II. — Under what conditions can good results be obtained with the Westinghouse drive, and what is the normal life of the spings ?

III. — Is it advisable to arrange for elastic (spring) transmission in the case of locomotives having connecting-rod drives, and should the gear be fitted with a shock absorber or not? Is it necessary to make special arrangements for adjusting the exact length of the connecting rod in service?

IV. — In geared locomotives, what system has been found to work best, and what is the method of lubrication adopted?

V. — As the result of present experience, is it better to adopt the connecting-rod drive or direct drive for high-speed locomotives? Can these locomotives be fitted with radial axles (Bissel or Adams) and in this case, what conditions must be observed (weight per axle, restoring force, etc.) ?

VI. — Has it been found that the presence of the oil necessary for the circuit breakers used with alternating current or with the transformers gives rise to any danger in working?

In that event, have any steps been taken to prevent risk?

VII. — What is the type of remote control that has given the best results up to date (electric, electro-pneumatic, mechanical, etc.) ?

VIII. — To what figure has the maintenance of a continuous current motor and an alternating current motor been reduced? What mileage has been found possible without examinations requiring more than one day?

IX. — What is the present mean distance run by electric high-speed locomotives as compared with steam locomotives of the same class? Are any steps being taken for operating electric locomotives by a single man, and if so, under what conditions?

[621 .138 & 725 .33]

QUESTION VI

(Locomotive sheds),

By G. FORTE, special reporter.

PREFACE.

This special report (1) summarises the three reports which have been prepared on the question of locomotive sheds, namely :

Report No. 1 (British Empire), by Mr. R. E. L. Maunsell (2);

Report No. 2 (all countries except the British Empire and America), by Mr. G. Forte (3);

Report No. 3 (America), by Mr. R. W. Bell (4).

For brevity, we will designate these as follows : report No. 1, *British*; report No. 2, *for other countries;* and report No. 3, *American.*

The *British* report confines itself strictly to the wording of the question, and gives, in a summarised form, the list of the replies received as regards running shed lay-outs and equipment arranged in accordance with a definite scheme; it also draws attention to various points of special interest in these, and is accompanied by drawings of their general arrangement and details.

The report *for other countries* gives a carefully arranged description of the more interesting details of engine sheds; it discusses the principal questions of organisation and arrangement, devotes a chapter to sheds for electric locomotives, and gives in the final summary deductions which have been arrived at.

The *American* report also summarises the information and gives a description of the construction and organisation of a typical shed; it describes its operation in practice and the more modern features and special equipment, giving the results obtained and the principal dimensions and characteristics. The information sent in in reply to the questionnaire is reproduced as an appendix.

In the present special report, in which we propose to summarise the three reports mentioned above, we do not think it advisable to give detailed descriptions of the various lay-outs, nor the reasons put forward in support of the opinions expressed.

We will therefore proceed by putting forward a proposed final summary which may be suitably discussed at the Congress, and will leave the remainder to the reports themselves.

The engine shed is considered in the first place from the point of view of its general arrangement and operation in reports Nos. 2 and 3. The latter report describes the movements of an engine from the time it enters the running shed yard until the time it leaves it, draws special attention to the necessity for external accommodation for engines, both when arriving and when departing, gives the successive order in which are

(1) Translated from the French.

(2) See *Bulletin of the International Railway Congress Association*, February 1925, p. 501.

(3) See *Bulletin of the International Railway Congress Association*, May 1925 (1st part), p. 1561.

(4) See *Bulletin of the International Railway Congress Association*, March 1925, p. 765.

to be arranged the various equipment for carrying out the operations which have to be performed on an engine, and lays down the amount of accommodation of this nature which has to be provided. We regret that we cannot deal with all these points one by one, but we will content ourselves with reproducing *in extenso* the general principles contained in the first paragraphs of the summary to report No. 2, which principles may be applied very widely and are likely to prove useful in the final discussion :

« 1. — The engine shed should be so situated and arranged that easy communication is assured by independent roads of a reasonable length, with the station to which it is to supply or from which it is to receive locomotives.

2. — It should be provided with the necessary means to carry out in an easy, rapid and economical manner :

a) all shed duties which have to be carried out on locomotives while housed in the shed;

b) maintaining in a good state of repair all engines belonging to the shed in question;

c) suitable accommodation and facilities for the employees.

3. — A shed has limits of capacity which it is not advisable to exceed, both as regards the number of locomotives which are assigned to it and also as regards the amount of repair work which it has to carry out.

4. — It is necessary that there should be the correct proportion between the number of engines assigned to the shed and the capacity of its accommodation, both in the shed itself and on the roads for engines outside the shed, and as regards its facilities for repairing, coaling and watering engines.

5. — In schemes for new accommodation, it is necessary to provide for all possible future requirements.

6. — A running shed consists of the following features : the shed itself, a repair shop, stores, coal stage and coal storage, and all accessory buildings and equipment. »

These are the principles laid down in the last paragraph which we shall follow in drawing up the present summary.

A. — Engine shed.

Type. — As regards type, sheds may be classified as follows :

a) Radial roads with a central turntable :

1° A square or rectangular shed;
2° A shed built as an annular sector or a round shed.

b) Parallel roads arranged side by side :

3° With long straight roads;
4° With short straight roads.

Type No. 1, with one or more such covered turntables, is in favour with some of the British administrations.

Type No. 2 consisting of one or two annular sectors with the turntable in the open, is adopted by nearly all the American railways (with the exception of small sheds, which are of type No. 3), and this is preferred, except under certain circumstances, by some of the other railways outside Great Britain, which are also dealt with in the British report, and it is also by the majority of administrations in other countries.

Type *b*), with long roads, and in particular type No. 3, is also used for preference by other administrations dealt with in the *British* report, and by a few dealt with in the report *for other countries.*

To summarise, type No. 2, the advantages of which are well known, is the most widely favoured. Information will be found in the figures and texts of the three reports as regards the capacity, arrangement and principal dimensions of sheds of this type.

Construction.

The *British* report and the *American* report give particulars of various details:

— on the form of the roof, which may be symmetrical with equal pitches or of the saw-tooth type of roof;

— on the various materials such as wood, iron, or reinforced concrete, used for the principal members of the roof;

— on the roofing material employed, there being many variations of this;

— on the various arrangements of windows and openings in the roof and in the walls to improve the lighting and ventilation;

— on the various types of doors used, although, however, reports Nos 1 and 2 state that these are not essential, at any rate where no local reason occurs making it necessary to provide protection against cold, wind or trespassers;

— on the type of floor used by the different railways, report No. 3 recommending and giving reasons why they should be made of wood.

The report *for the other countries* is briefer on this subject; it mentions other types and materials for roofing, draws attention to the present day practice to use concrete in constructing running shed walls, and points out the advantages.

Special equipment.

a) *Pits.* — These are largely employed inside the shed for cleaning, inspecting, repairing and washing out locomotives, and also in some cases for carrying out inspection and minor repairs outside the shed in proximity to the entrance.

Report No. 2 mentions the use of pits for all the roads in the shed intended for accommodating locomotives, and reports Nos. 1 and 3 give the principal dimensions, and describe some typical examples as regards design, method of construction, lighting and drainage.

b) *Recovery of oil from cotton waste used for cleaning purposes.* — The report *for other countries* mentions a plant of this nature which is in operation at the engine shed at Schaerbeek (Belgium).

c) *Facilities for carrying out light repairs to engines in the shed.* — The following may be mentioned :

— supply of electric current for portable drills and lamps;

— supply of compressed air for pneumatic tools;

— inspection pits or drop pits provided with means for removing a pair of wheels, report No. 1 giving a drawing and report No. 3 a description of these. They are very widely used.

d) *Arrangements for washing out and refilling boilers.* — The *British* and *American* reports mention a general preference for hot washing out and state that this is widely used; the report *for the other countries,* while recognising the undeniable and well known advantages of this system, has to confess that the practice of washing out with cold water is still very generally adopted.

In addition to the ordinary water supply for washing out, use is made of injectors supplied with steam from a central boiler or from another locomotive on an adjacent road, or of motor driven pumps, and in the case of some of the larger sheds, of special plant for providing hot water.

Report No. 3 describes, under this heading, the type of plant most widely used in America, and report No. 2 mentions a special installation for recovering the heat contained in the water run off from boilers similar to that adopted on the Italian State Railways and on the Belgian State Railways.

The same installations which provide hot water for washing out, provide water

for refilling boilers; but as regards the temperature of the water, report No. 2 points out that although washing out with hot water followed by refilling with hot water assists in reducing the time during which a locomotive is kept out of service, too high a temperature for the washing out water and subsequent refilling with water and steam under pressure gives rise to difficulties and dangers in handling the apparatus and is detrimental to the boiler plates.

The temperature obtained and adopted with the above mentioned installations for recovering the heat gives a temperature of about 55° C. (131° F.) for washing out, and 85° C. (185° F.) for refilling the boilers.

These plants prove satisfactory if their simplicity and consequently moderate cost of erection and upkeep compares with the amount of heat regained, or in other words, if the amount of coal saved shews an overall economy. These requirements have been found to be satisfied in some cases, provided that the plant is efficiently handled and that a sufficient number of engines are being simultaneously emptied and washed out each day.

e) *Lighting up locomotives.* — The most generally used method is to employ wood, which is lighted in the firebox with discarded pieces of oily waste. Some administrations use live coals from special fires which are used for drying the sand, warming water, or other purposes.

Another method consists in spreading a layer of coal in the box, spraying this with oil by means of a jet of air and steam mixed and then igniting this. Other railways on the other hand, as is shewn in a table attached to report No. 1, use special fire lighters made of wood soaked in inflammable material, or else an oil flame projected on to the coal by means of compressed air. The rate at which steam is raised in the early stages may also be accelerated by using a blower supplied with steam from another source, but report No. 1 does not recommend this method.

f) *Special provision for removing smoke.* — Special arrangements are generally recognised as being necessary.

However, mechanical installations for this purpose are very rare; the *American* report mentions several types with underground or overhead conduits leading to a central chamber from which the smoke and air are discharged into a chimney, either directly or after having been washed by contact with water. Such installations are only used where local regulations render it necessary.

The provision of a tall central chimney and a system of closed hoods or flues fitting on the chimneys of the engines are adopted by some European administrations. As it is recognised that these are effective in reducing the time necessary to raise steam and also for heating the shed, they are still in favour on certain railways; however, the majority are not convinced of their practical utility or convenience for two reasons : firstly because engines cannot always be placed at one definite position during the whole of the time they are in the shed, and secondly because the cost of erecting and maintaining such devices is considerable.

Therefore, the type which is most preferred, which is the only one mentioned in the British report, is that which consists of fixed hoods with separate chimneys constructed of concrete, asbestos, « eternite » or wood, with a rectangular opening, having its greatest length along the line of the track and — in the case of long parallel roads in rectangular sheds — the tops of the troughs are sloped upwards towards uptakes which are provided at intervals of about 6 m.

There are, however, a number of administrations who, instead of employing arrangements of this kind, content them-

selves with providing sufficient natural ventilation.

g) *Lighting and heating of sheds.* — The most generally adopted form of artificial illumination is electric lighting, preferably with incandescent lamps, which is rendered still more convenient by the use of portable lamps for inspecting and repairing locomotives. However, there are a number of examples where gas lighting is used; report No. 1 gives a photograph of an installation of this kind.

For heating sheds, report No. 2 states that during very cold weather, the administrations concerned still use, as a rule, stoves or braziers, stating that the latter have very little effect on the general temperature in the shed, and serve rather as a means of warming ones hands, using a large amount of fuel and causing damage to the building.

However, in very cold climates in the more important sheds, central heating apparatus using steam or hot water are employed. This latter system is the most satisfactory, but it entails considerable first cost; report No. 3 gives details of this, and states the advantages gained.

B. — Shed workshop.

Report No. 2 deals at length with workshops at locomotive sheds, considered as a separate feature; it discusses the work which is required to be undertaken and gives information as regards the lay-out, principal dimensions and equipment, dealing especially with lifting tackle, this being also dealt with in the other two reports. It expresses an opinion on the type and capacity of the machine tools (report No. 3 gives two typical examples of the machine tool equipment) and calls attention to certain equipment which has been found to be of utility. It draws up the following conclusions, which we will reproduce *in extenso*, because, although only applying to other than English speaking countries, they may be of utility and serve as a basis for a useful discussion :

« 1. — Generally speaking, the running shed must carry out all repairs to its locomotives, other than heavy repairs, and maintain them in good order. In order to do this, not only must small repairs and partial overhauls be done, but a carefully thought out programme should be laid down for each engine of the medium repairs to be carried out. In each case it has to be decided if the running shed should carry out special repairs of considerable extent, bearing in mind the equipment of the shed and extent to which it is available, and the speed and ease with which the repairs can be carried out.

« 2. — The lifting and erecting shop should be able to contain 8 to 12 % of the engines stationed at the running shed, and sufficient pits should be provided for this number; some would be used for inspection or changing wheels and axles. The shop should be fitted with the necessary appliances for lifting the engines quickly and safely, such as screw jacks, stools and cranes of sufficient capacity. A rectangular shop with short parallel roads is the most suitable for this purpose.

« 3. — It is possible to arrive at a ratio between the number of locomotives at a running shed and of the machine tools with which the shop should be fitted.

« 4. — Of special machine tools, wheel lathes and vertical boring mills for dealing with piston rings are most useful at a running shed.

« 5. — Compressed air and oxy-acetylene welding are of great use at a locomotive shed; on the other hand, plant for repairing tubes and springs is not to be recommended. »

C. — Stores.

Report No. 2 discusses in a general manner and also in detail the functions

of the different stores at a running shed, which should meet the periodical demands for consumable stores and which should also stock material which it is convenient to always have available for immediate use should the necessity arise. The material which is kept in stock may be divided in accordance with the following four categories :

a) Tools or equipment for temporary issue or as a reserve stock;

b) spare parts or material;

c) lubricants and paraffin;

d) various consumable stores for use on locomotives and by the staff.

The most important of these stores, from the point of view of the organisation and special equipment, is that which deals with the storing and distribution of lubricants and paraffin; this is dealt with in particular by the two other reports.

The oils are contained in metal reservoirs, either cylindrical or rectangular, placed on the ground floor or in an underground cellar, so that the wooden or metallic casks or tank wagons, in which the oil is delivered, are emptied into the same by gravity, or by mechanically operated or hand pumps, or by a vacuum formed in the above mentioned reservoirs. The checking of the quantities received do not present any special features worthy of mention; the oils are generally issued in measures of known capacity, or in some cases by being weighed, either directly or by means of automatic measuring devices.

Report No. 1 also states that for the thicker oils in colder climates means are provided for warming the oil in the reservoirs or for heating the surrounding air.

Report No. 3 also mentions a tool store provided for receiving tools and other equipment from locomotives on their entering the shed for cleaning, and keeping these in repair and issuing them to out-going engines, this being the practice in American running sheds.

D. — **The coal stage.**

Special equipment is generally used at the more important sheds for handling of coal rapidly and economically.

The *British* report reviews the methods employed with this object, and briefly describes in the first place three types of mechanical coaling apparatus in use on British railways, two of which have conveyors for directly distributing the coal or for filling coaling hoppers, the other lifting a wagon and tipping the contents into an elevated coal bunker. It also mentions steam cranes and coal stages at the top of an incline for the distribution of coal by gravity, either by means of direct unloading from hopper wagons into bunkers from which it falls into the tenders which are placed underneath, or else by means of tubs which can be loaded directly from wagons with side doors and then tipped on to the tenders.

The *American* report gives information on the use of transporters for conveying coal to elevated coal bunkers at the more important sheds, and of bucket conveyors in the smaller sheds, and gives the various methods of obtaining small coal for engines fitted with mechanical stokers.

The report *for the other countries* recommends that manual handling of the coal should be retained at small sheds, aided in some cases by simple and cheap mechanical devices. It also mentions mechanical coaling plants and lays down that the choice of suitable equipment should depend on the amount of coal which has to be handled and on the rapidity with which this has to be done, and gives the cost of erecting and operating each type of plant and the limits which can easily be determined within which these may be economically employed and which type of apparatus is the most suitable. It mentions overhead cranes as being the most suitable where a sufficient amount of coal has to be

handled, and gives a balance sheet for the types of coaling plant used.

Coal when issued is as a rule from time to time weighed or measured in order to obtain the necessary control and statistics.

In accordance with report No. 2, the different qualities of coal are generally distinguished as screened, run of mine and slack, and distributed separately in various proportions in accordance with the type of engine and service which it has to perform. On the majority of railways dealt with, a mixture of coals of various qualities is made only in exceptional cases. For this purpose there are in existence simple systems, and there has recently been constructed at Schaerbeek (Belgium) a complete installation for mixing and distributing the coal, the principal characteristics of which are given in the report.

E. — Buildings and accessory equipment.

1. — PROVISION OF SAND. — Simple methods of artificially drying sand are used, and report No. 1 gives drawings of two types of furnaces in use for this purpose, while report No. 3 describes other drying apparatus, either with a furnace or by steam pipes. There are also examples of mechanical means or compressed air devices for handling the sand before or after drying, and such methods are coming into use, especially at the larger sheds.

2. — REMOVAL AND DISPOSAL OF ASHES, ETC. — For the smokebox char, report No. 1 gives a method of removing this by means of a steam ejector. Report No. 3 states that in America locomotives are now constructed in such a way that they automatically discharge smokebox ashes through the chimney by means of the draught produced by the exhaust.

For removing ashes from the ashpan, as a rule ashpits are used, which are provided in some cases with jets of water for slacking the ashes; in most cases mechanical means are used for removing the ashes and loading these into wagons. Reports Nos. 2 and 3 mention or describe some of these methods, and report No. 1 gives three other typical examples of this kind.

The recovery of coke from the ashes, done either manually, mechanically, or by means of electric-magnets, is adopted by the majority of the administrations dealt with in the report *for the other countries* and by one of those mentioned in the *British* report. The smokebox char is recovered separately, and in some cases is used for small suction gas plants, or as a fuel in the form of brickets or mixed with coal. In America, however, no method of recovering or separating the coke is adopted.

3. — METHODS OF CLEANING TUBES. — For cleaning the ordinary small tubes, rods are still used, especially where it is necessary to remove incrustations of soot and cinders; however, the use of compressed air, or steam from an engine under pressure by means of a special jet, is stated to be extending. Similar devices are used to blow out large superheater flues, these being generally blown out from the firebox end.

Report No. 2 also mentions good results obtained by fixed steam jets provided inside the firebox which allow tubes to be blown through while running and rendering it unnecessary to clean these at the shed.

4. — CLEANING LOCOMOTIVES. — Besides ordinary hand cleaning with cotton waste and oil or other material, which is the method generally used, the *American* report mentions methods of mechanical cleaning consisting of washing with a mixture of warm water and oil applied by means of compressed air, especially for wheels and motion.

5. — WATER SUPPLY. — This includes, where necessary, pumping plant, reser-

voirs of such a capacity as to form periodical, temporary or permanent reserves, water columns suitably provided on the in-coming or out-going roads from the shed, mains, standpipes, and other apparatus as a safeguard against fire, and all other accessories for the various requirements of the shed, workshop and staff.

The softening and purification of water used for locomotive purposes is extending. This is done with the object of obtaining a better life from the boilers and a longer period in service of the tubes, with an economy of fuel and a reduction in the amount of washing out. Moreover, it allows local surface water to be used, even when this is of poor quality, instead of better water from a more distant source or which is less abundant or more expensive.

In this connection, report No. 1 states that on some railways the results given by softening plants have not been, in the first place, sufficiently satisfactory for this process to be preferred to the treatment of water by means of chemicals introduced directly to the tender or into the boiler.

However, the author of this same report states that he cannot agree with this unfavourable opinion, and recommends, as do also the other two reports, the purification of water by decantation and filtration, or softening by chemical means by means of apparatus connected with the reservoir; these apparatus are now used on a large scale, and the *American* report gives detailed descriptions of these.

6. — Turning locomotives. — This is generally done on turntables consisting of rigid girders balanced about a central pivot, or, in a more recent system, carried on three points of support.

It is to be recommended that the turntables should be of uniform type and of uniform diameter, and it is convenient to operate these by electric motors, or where this cannot be done, by other mechanical means. Mention is also made of a number of examples of triangular, star shaped, or circular tracks, for turning engines, either in place of the turntables, or as an emergency measure should these be out of action.

7. — Accommodation for the staff. — a) *Dormitory.* — This consists of rooms with one or two beds and also includes lavatories and water closets.

b) *Baths, changing rooms and lavatories.* — There is a tendency to increase the amount of accommation of this kind, regardless of expense, in the interests of the health and wellbeing of the staff.

c) *Dining rooms and sitting rooms.* — The former, either with or without organised canteens, are provided in view of the increasing demand for better conditions. The latter, together with recreation rooms, on the other hand, have developed to a lesser extent, but have been provided in special cases and are included in the most recently constructed sheds.

8. — Offices and other accommodation. — The former are provided for clerical work in connection with the control of the running shed, workshop and stores, or for technical and administrative purposes. The latter are used for instruction classes for the working engines foremen, as a pay office, for the caretaker, in connection with sanitation, for storing bicycles, or for other special purposes.

9. — Heating apparatus, provision of hot water, illumination and telephone communication. — We have already examined this question as regards the shed itself. For the remainder, report No. 1 also states that the use of electric light with incandescent lamps is the most satisfactory and the most widely used, but it also quotes cases in which high pressure gas lighting is preferred.

Report No. 3 states that arc lamps are the best method of lighting large spaces in the open.

Report No. 2 recommends a central plant for providing hot water and heating the offices and buildings.

Running sheds for electric locomotives.

These are only dealt with in report No. 2, which draws attention to the essential difference between running sheds for steam and electric locomotives, therefore we must content ourselves with giving the following brief summary :

« Rectangular sheds are better for electric locomotive depots. These running sheds differ from those for steam locomotives, not only because certain equipment is not required, but also by the fact that they have to be higher and more completely closed in. They also require properly equipped bays for carrying out work to electric parts, a greater number of lifting jacks, machine tools, etc., a larger staff, and a larger stock of spare parts. They also need more space and a greater distance between lines, both in the shop and in the shed. »

However, as the question of running sheds for electric locomotives is not dealt with by the two other reports, or in the questionnaire attached to report No. 2, the above mentioned summary should be considered as having only a special application until such time as they are confirmed by a wider review on this subject.

FINAL SUMMARY.

The summary which we have just given as regards running shed equipment, which in the interests of briefness is merely a broad outline, is based on three reports which are drawn up on somewhat different lines, so that descriptions given or conclusions arrived at in one report cannot always be compared with similar questions or conclusions in the other two reports.

On the other hand, it is from a careful examination of each of these reports taken separately that the present brief outline and combined report which we have given here has been prepared.

Finally, in choosing lay-out and equipment of this kind, various local conditions and special circumstances have a bearing, apart from considerations of a technical nature, which prevent any hard and fast rules from being drawn up. For this reason we do not propose to draw up any definite conclusions.

Moreover, the few conclusions which might be arrived at would only be a repetition of what we have already said.

It would appear that the most useful line of discussion at the Congress would be to examine the various points dealt with in this report in the order of the various successive chapters, on the understanding that everyone is fully conversant with all the information given on the various subjects in each of the reports.

SECTION III. — WORKING.

[656 .254]

QUESTION VII

(Dispatching system),

By E. EPINAY, special reporter.

The present special report [1] summarises the three reports which have been prepared :

1° by Mr. J. H. Follows for the British Empire [2] ;

2° by Mr. F. P. Patenall for America [3] ;

3° by Mr. E. Epinay for other countries [4].

It will be remarked in the first place that the wording of the question itself has been the subject of comment by Mr. J. H. Follows. He remarks that the expression « Control System » only is used in the British Empire, though in his opinion the two expressions, « Dispatching System » and « Control System », must be regarded as synonymous. This is also our opinion.

As, moreover, the word « dispatching » is used in practice in a much more general sense than is justified by its literal signification, and as, on the other hand, the word « control » has by no means the same meaning in English and in French, it would be useless to attempt to draw a clear line of demarcation between the two parts of the double title of the question.

In order to avoid any confusion in the terms employed we shall use the expression « Dispatching System » in speaking of the railways of the Continent of Europe and of America, although in the case of certain railway administrations this is not the expression which has been officially adopted. As regards the British Empire, on the other hand, we shall keep to the expression « Control System », which is the expression generally used there.

In our summary report we shall as a general rule use the following nomenclature : « scheduled trains » for trains which run daily throughout the year or during certain periods of the year (according to the normal distribution of traffic); « auxiliary trains » for trains whose journeys are laid down in advance in the timetable, but which only run specially ordered; « special trains » for trains whose times are not fixed by the timetable, their journeys being arranged immediately prior to departure, according to the needs of the moment; « trains without a fixed itinerary » for trains which not only do not appear in the timetable, but which also leave the starting station without a pre-arranged timings.

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(1) Translated from the French.

(2) See *Bulletin of the International Railway Congress Association*, February 1925, p. 389.

(3) See *Bulletin of the International Railway Congress Association*, April 1925, p. 1085.

(4) See *Bulletin of the International Railway Congress Association*, March 1925, p. 619.

I. — REPORT OF Mr. J. H. FOLLOWS.

GENERAL.

The « Control System » is in force in the British Isles on the London Midland & Scottish Railway (L. M. S.), the London & North Eastern Railway (L. N. E.) and the Great Western Railway (G. W.); as regards other parts of the British Empire, the system is adopted on a certain number of railways in India, on the South African railways, on the Federal National Railways of Canada and on the Federal Railways of Malaysia.

The *primary object* of the « Control System » is the regulation of the running of trains and engines, and of all correlative movements on the rails; that is to say : the observation by trains of the times contained in the timetable; the running of auxiliary or special trains for cattle, perishable foodstuffs and other goods, when the scheduled trains are insufficient to cope with the traffic; the satisfactory utilisation of the tractive power of the engines, and the handling of traffic under the most economic conditions possible; the loading of trains to their maximum capacity; the alteration of the route, or the cancelling, of trains in case of accident or fouling of the lines; the close supervision of the quantity of traffic with a view to the running of complete trains for maximum distances with a minimum of stopping places; the regulation of traffic in the neighbourhood of terminal stations; the taking of the necessary measures for the carriage of goods which do not come within the ordinary forms of transport.

The « Control System » may also be extended to *other activities, e. g.*, the distribution of rolling stock; the regulation of embarkation; the relief of drivers, firemen and train staffs, so as to avoid exceeding the regulation hours of service; the rotation of service of train staffs; the drawing up of timetables and diagrams of train movements.

A « Control System » such as described above can be organised in one or other of the four following ways :

a) the whole of the operations over the whole of the railway system may be controlled from a single central office;

b) the railway system may be divided into districts, each district having its own control office, responsible to a central office which ensures that there is coordination of working between the different districts;

c) the railway system may be divided into districts, each district having its own control office, responsible to a divisional control office, the divisional control offices being in turn responsible to a central control office (this is the method adopted by the L. M. S.);

d) the railway system may be divided into districts, each district having a control office responsible to the head of the working service of the district or division with control from a central office, as in the case of the G. W., and without such control, as on the L. N. E.

As a general rule the control organisation exercises the following functions in respect of the traffic it controls :

1° It decides as to the running of auxiliary or special trains, and as to the cancellation of scheduled or special trains which have proved unnecessary;

2° It gives to signalmen (¹), where necessary, the appropriate orders for modifying the order of succession of trains with a view to improving the general movement of traffic.

All employees who have occasion to get into touch with the control office must be able to do so (and the control office must also be able to get into touch with such employees) without delay; for this purpose use is made of the Morse telegraph or of the telephone.

We may mention, as an example of an organisation which fulfils the above conditions very efficiently, that of the L. M. S.: special telephone lines between Derby (office of the Chief General Superintendent) and the divisional control centres of Derby, Crewe, Manchester and Glasgow; between the divisional control centres and the district control centres; and between neighbouring district control centres; further, the facilities which exist for rapid communication between district control centres and stations, shunting yards, signal posts, and locomotive and train staff depots.

For calling up both posts on the permanent way and control centres, use is ordinarily made of conventional signals based on the Morse Code, generally with an independent call for the control office by means of a separate key and sometimes by special keys for certain branches of the service (for example, a special key for calling up the train controller, and another special key for calling up the engine controller).

The selector telephone is used by several British railways, and its use has been considerably extended on the railways of the colonies.

Information with regard to the running of trains is telephoned to the district control centre (and to the divisional control centre in respect of traffic which it follows directly) by the posts concerned, generally signal boxes, and sometimes stations.

This information varies according to the method of organisation adopted, and comprises all or part of the following: time of departure from starting station and of arrival at terminal station; time of passing through, arriving at or leaving the intermediate stations which report such information; number of the engine; situation, from the point of view of working conditions, of the driver, fireman and guard; load of train; in the case of passenger trains, degree of utilisation of the capacity of the train (small, normal, full or excess load).

These particulars are generally entered by the control office on forms or maps.

Special systems are adopted to enable the staff of the control offices at any moment to have a general view of the situation of the trains within their control district.

The system usually preferred is that of the *Train Board*, as used particularly by the L. M. S. for the control of goods traffic.

The Train Board generally takes the form of a blackboard, along the vertical edges of which are written the names of the more important stations and branch lines: to the right of each of these names there are two rows of holes, the spacing of the holes in each row corresponding to interval of 5 minutes. One of the rows is used for recording arrivals, and the other for departures and non-stop passage through stations.

At each announcement the peg which holds the card kept for each train is placed in the appropriate hole.

On one side of the Train Board there is a free space to hold temporarily the cards corresponding to trains temporarily held up.

On certain railways, also, use is made

(¹) Signalmen : It may be weel to point out that in England the signal for departure is not generally, as on the Continent, given to the train by a station employee. The signal arm having been lowered, the train starts on the order of the head guard.

of a geographical plan of the lines, on which, according to the information received, pegs are moved about, these pegs holding cards corresponding to each train, or discs on which the number of each train in the timetable is printed.

The L. N. E. uses a special type of Train Board at York. It consists of a board along which are marked the names of the stations, and in front of which move a certain number of endless cords worked by a clockwork mechanism at speeds corresponding to the different classes of trains (there are five of these cords for up trains and five for down trains).

The card corresponding to each train is attached to the cord corresponding to the speed of that train.

In order to avoid the possibility of giving a wrong indication, there is an arrangement for stopping the cards at certain station names, and it is necessary for an employee to attend to the board before the cards can pass these points.

Control of goods trains.

The methods of controlling goods trains are particularly interesting.

In the first place these trains cannot, in the nature of things, run with the same punctuality as passenger trains, in view of the nature of the work they have to perform during the journey. Thanks, however, to the « Control System » it is possible to attain the maximum regularity by following closely all the trains, ordering changes in the running order of trains where necessary, and inquiring immediately into all cases of delay; the effect of such action is to keep the employees constantly alert.

On the other hand, whereas the make-up of passenger trains is fixed in advance once for all (subject to duplication or to the carrying of extra loads on occasions when traffic is unusually heavy), the make-up of goods trains varies from day to day, as does also the number of trains necessary to carry the traffic. The control organisation's duty is to see that the number of trains is as nearly as possible in proportion to the traffic to be dealt with, and to ensure that the capacity of the engines is fully utilised. For this purpose the control staff is supplied periodically with information from the more important stations as to the volume of traffic actually on hand, and also as to the traffic to be expected within the next few days.

The following particulars relating to the L. M. S. will be of interest.

On this railway signalmen have general instructions to hold up trains which are late if there is a danger of such trains delaying other trains which are up to time.

The more important trains are followed not only by the district control centre, but also by the divisional control, and this dual supervision is a means of stimulating the diligence of the employees.

In case of bad weather in a given district, the divisional control office is advised of the fact, and he decides whether or not it is desirable to cancel certain trains in order to clear the line for more important trains.

Each morning (or more frequently if the situation justifies it) a telephonic conference is held in each division between the divisional controller and the district controllers, in order to decide as to the running of whatever auxiliary or special trains may be necessary and as to the cancelling of any scheduled trains judged unnecessary.

During the conference cases of train delays are fully inquired into.

Relief of train staffs.

It may be well to point out in the first place that on the former Midland Railway (which now constitutes the Midland division of the L. M. S.) the control organisations came into existence as a result

of the difficulties experienced in arranging the relief of train staffs.

Before the institution of such organisations, train staffs were either liable to be called upon to work excessively long hours, or in the alternative it was necessary to allow them the right to request their relief themselves, both of which alternatives were open to serious objections.

The control centres, when they have to arrange the relief of train staffs, are linked up by special telephone lines, or at any rate telephone lines allowing of rapid communication with engine sheds and train staff depots.

The control centre is notified, in the case of each train the work of whose staff is under its control, of the number of the engine, the name and the home depot of the driver and head guard, and the period of service completed by each of these employees before the departure of the train.

The control office enters this information on suitable forms or cards, and is thus able to ensure that all employees are relieved at the appropriate time.

On certain railways the control centre is empowered to regulate directly the service of train staffs; on other railways the centre acts as intermediary between the train staffs and the depots.

Control of special traffic.

The control centres in many cases control any special traffic which may exist, as for example the transport of coal consigned to ports of embarkation or to London.

The principle of such control is not to permit the loading of goods at the dispatching station unless the receiving station is in a position to accept them.

In the case of the transport of coal to London, for example, the acceptance of consignments for a given consignee depends on the situation at London as regards previous consignments to such consignee.

It is the practice in England to refuse to accept consignments for a consignee who is not in a position to take immediate delivery of the wagons on his sidings or to make arrangements for their prompt unloading.

The regulation of special forms of traffic is effected by the different sections of the control organisation according to the nature of the traffic and the length of the journey.

In the case of the carriage of coal consigned to ports of embarkation, the control staffs keep in touch with the authorities in charge of the port concerned.

Control of passenger trains.

The main object of the control of passenger traffic is :

1° to ensure the punctual running of the trains and to be in a position to deal without delay with occasional rushes of traffic;

2° to ensure the most economical use of vehicles carrying excess loads and of special vehicles.

On the L. M. S. in particular, apart from the district control, express trains are followed directly by the divisional control.

It is the duty of the divisional control to take all important decisions affecting express trains (cancellation or observance of connections; holding up of trains to allow express trains to pass; ordering of relief trains, or, in the case of accidents resulting in the obstruction of the line, diverting or cancelling trains).

On the L. M. S. the divisional controller alone is authorised to order a change in the normal make-up of passenger trains.

In order to enable the divisional con-

troller to have a clear view of this section of his work, his office is equipped (in addition to diagrams showing the normal make-up of each train) with wall diagrams on which the supplementary vehicles which have been ordered are represented by cards hanging from pegs.

The controller is thus in a position to know at any given moment the exact state of every train within his area.

If the additional tonnage asked for is beyond the capacity of the engine, the controller either arranges for some other means of transport, or consults with the traction department as to the use of an auxiliary engine.

As regards supplementary vehicles to be added to ordinary trains, stations must submit their proposals at the same time as they state their requirements.

Accidents and bad weather.

In case of accident or bad weather the control offices have the power to take all steps necessary to ensure the continuation of traffic, either by cancelling or diverting certain trains. In case of fog, in particular, the controllers must take the necessary measures to ensure the regular running of whatever reduced traffic may be possible under the circumstances.

Distribution of rolling stock.

The distribution of rolling stock may be effected either by the control offices themselves (L. M. S. for example), or by special departments (L. N. E. for example). In the latter case the distribution service can be greatly facilitated by the use of the control telephone system.

The distribution service is in three sections : central, regional and local.

The difference between the quantity of rolling stock available and that needed at each of these three sections is made up in the first place from the local or regional resources in each distributing centre : these differences are notified to the next higher centre, which gives the necessary orders for making up such differences.

The distribution of vehicles for express trains or special slow train vehicles is, however, generally done from the central distributing depot.

Timetable department.

It is advisable that the department responsible for the compilation of timetables should work in collaboration with the control centres. This collaboration is a feature on the L. M. S. in particular, where the timetable department is situated in the offices of the Chief General Superintendent at Derby, in the immediate neighbourhood of the control offices.

Control staff.

As regards the constitution of the control staff, certain administrations recruit it from among the employees of the traffic service and others from the office staff.

It is not possible to lay down any general rule on this subject, but there is an apparent tendency to appoint younger employers to the control staff as soon as they have acquired sufficient experience of actual line work, and provided, of course, they have the necessary aptitude for the work.

General observations.

The telephone is the basis of every control organisation, but it must not be forgotten that it is in reality a means and not an end.

The first thing to be done in connection with the working of a line is to ascertain its maximum capacity, then to compile the train timetable on the basis of the traffic to be handled, making it

a rule to provide scheduled trains wherever justified and possible.

It would appear desirable to adopt a centralised control system for passenger trains and for the distribution of rolling stock, except on railways where train journeys are very long, as for example the railways of the American Continent.

The decentralised method of district control, with a central or co-ordinating control organisation, appears the system best adapted for goods traffic.

It seems desirable that district controllers should be responsible to specialist officials of the control service, in order to avoid interference which might be detrimental to the satisfactory working of the service.

The possibility of an effective control of trains and traffic would appear to be considerably augmented when employees of the Traffic and Motive Power Departments are placed under the authority of a single chief, and when the control office is empowered to give orders to employees of he Motive Power Department.

The control of the work of train and engine staffs (guards, drivers, firemen) appears to be equally facilitated when such employees are placed under the authority of the Traffic Superintendent.

It is essential that the control organisations should not consider themselves as a kind of machine for recording the running of trains and cases of delay, but that they should take an active and intelligent part in ensuring a satisfactory train service.

Finally, the control office should not be burdened with office work not directly connected with train movements.

II. — REPORT OF Mr. F. P. PATENALL.

The system of « dispatching » or of « control », or in other words the method of directing from a central point the movement of traffic over a certain zone of railway, has as its object the execution of the largest possible number of train movements in the shortest possible time, thereby effecting economies in the cost of working.

In the Standard Code published by the American Railway Association with a view to formulating the general principles which should govern railway working, there is a rule which places the control of train movements in the hands of a dispatcher who has authority to give orders to the signalling staff.

Mr. Patenall circulated his list of questions to the 25 American railway administrations which are members of the International Railway Congress Association, and in his report he reproduces the replies received from each.

The dispatching system is adopted in America on single as well as on double line. The dispatcher is in contact with the various posts of the controlled area by means of the Morse telegraph or the telephone, the selector telephone also being widely used. These posts transmit to him such information with regard to train movements as will enable him to fulfil the duties assigned to him on the various railways, as for example departure and arrival times, delays, incidents occurring on the line, the loading of trains, the number of the engine and guard's van the name of the driver and head guard, and the amount of traffic to be dealt with at the various stations.

This information is entered on forms specially provided for the purpose.

The dispatcher generally controls both passenger and goods traffic.

He is generally responsible to a chief dispatcher who controls the whole of the traffic operations within a divisional area.

In most cases the dispatcher is authorised to give all necessary instructions with regard to the running of trains (changing of passing or overtaking places on single line, the running of trains into sidings on double line; the fixing of these points when one of the trains is running on an undefined timetable; modification of the right of priority of trains when the overtaking, passing or shunting points are regulated according to the priority system; the running of goods trains in advance of their timetable when this is considered desirable with a view to avoiding the congestion of the line).

The dispatcher may also be authorised in certain cases to cancel scheduled or special trains, to control the movement of shunting engines, material trains or workmen's trains on main lines, to regulate or superintend the load of trains according to the service to be performed, to order special trains, shunting engines and relief trains.

In certain cases the operations indicated above may be under the control of the chief dispatcher; they may occasionally necessitate the intervention of the superintendent.

On certain railways the dispatcher regulates traffic in the direction of ports and terminal stations; on other railways this duty is undertaken by the chief dispatcher.

The relief of train staffs is entrusted to the dispatcher on certain railways; on other railways he can only take action to prevent the violation of the federal laws relating to the work of drivers, firemen and train staffs; on other railways, again, the dispatcher has no authority in this connection.

The dispatching of goods trains and engines from terminal goods stations does not usually require the intervention of the dispatcher or chief dispatcher. It is generally in the hands of the station or depot superintendent.

When two or more adjacent sections are controlled by different dispatchers, co-ordination is always assured either by situating them in neighbouring premises where they can communicate with each other verbally, or, where this is not possible, by providing them with telephonic communication.

As a general rule the railways referred to in the report are of the opinion that the dispatching system has improved the punctuality of trains, accelerated the transport of goods, reduced working expenses, reduced the time during which trains occupy the line, increased the tonnage carried per train-kilometre and reduced the journey of engines per effective ton-kilometre. The increased expense on correspondence and telephonic communication is far less than the increased economies which it has been possible to effect by the adoption of the dispatching system.

On many of the railways of the United States, moreover, the dispatching system has been in operation for many years, and this renders it difficult to compare it with other systems of working.

III. — REPORT OF Mr. E. EPINAY.

In countries other than America and the British Empire the dispatching system is in operation :

a) Over the whole of the lines of the Norwegian and Swedish State Railways;

b) On all the important lines of the Belgian State Railways, the French Eastern Railway and the Paris-Lyons-Mediterranean Railway (P.-L.-M.);

c) On lines where traffic presents cer-

tain special problems on the French State Railways, the Paris-Orleans Railway (P.-O.) and the French Midi Railway;

d) On the lines of the Catalonian Railways of the Madrid-Saragossa-Alicante Railways (M.-Z.-A.).

Further, the dispatching system is being tried at the present time on the lines of the Northern Railways of Spain.

It may be remarked in the first place that the dispatching system in operation on the M. Z. A. railways is of a special character. On these railways the dispatcher does not normally take any action with regard to the running of trains. His main duty is to ensure a satisfactory goods traffic by controlling the dispatch of wagons, to order auxiliary or special trains where required, and to see that the necessary engines and staffs are provided for such trains.

On all the other European railways the principal duty of the dispatcher is to control the running of trains on the basis of a timetable comprising both scheduled and optional services.

Except on the lines of the secondary railways of Czechoslovakia, the action of the dispatcher is always exercised through the medium of the station service officials, who are responsible for giving orders to trains, whether such orders emanate from the dispatcher or from such station officials.

On sections which are under the control of a dispatcher, this official is in direct communication with stations and traffic posts throughout the controlled section, either by means of the telegraph or by telephone, with conventional calls in the Morse Code.

On certain Swedish and Norwegian lines, and in general in Belgium, Spain and France, use is made of selector telephones.

The dispatcher is kept constantly informed as to the state of traffic on the section under his control by the communications which he receives from stations on traffic posts (from head guards on the secondary lines of Czechoslovakia), such communications covering times of arrival and departure, the passing or overtaking of trains, and delays exceeding a certain limit.

The dispatcher enters the information thus received on appropriate forms or registers, or on a diagram showing the actual running of the whole of the trains on the line.

On lines thus equipped, and where the dispatcher has all the above information at his disposal, his duties may vary between two widely differing conceptions: that which regards the dispatching centre as the « sole control post on the section », and that which regards it as an « information bureau ».

If the former conception is held, the duties of the controller are :

a) Before the marshalling of trains :

to decide as to the necessity for running auxiliary or special trains, taking into consideration the situation of the dispatching and terminal stations, the means or traction available, and the method of making the best possible use of the capacity of the engines; to assure himself that the route chosen for an auxiliary or special train is compatible with other train movements already scheduled or already taking place on the line; when the running of a train has been decided, to notify the fact to the stations and depots concerned so that they may in due time provide the engines and employees necessary.

b) After the trains have been dispatched :

to decide as to shunting or change in the order of trains on double line, changes in crossing or overtaking points on single line, and to require stations to carry out the decisions arrived at; in

case of accident or breakdown, to order the relief engine and to make the necessary arrangements for its journey; to arrange for temporary single line working in case of obstruction on a double line.

On railways where the dispatching centre is regarded as an « information centre », there is no modification in the rules applicable to lines on which the dispatching system is not in operation, whether as regards decision as to the necessity for running trains, or as regards the action required to be taken in connection with trains which have actually been dispatched.

The first conception obtains on the Swedish State Railways, the Norwegian State Railways, and the controlled secondary lines of the Czechoslovak State Railways; on the P. O. Railway of France, the powers of the dispatcher as regards trains which have begun their journey also answer to this conception.

With the exception of the above cases, the dispatching organisation is intermediate between the two conceptions described above.

It may also be said that, as regards matters outside the province of the dispatcher, he still acts as an adviser, and his advice is invariably acted upon by stations. In particular, stations do not order a special or auxiliary train without having previously assured themselves that the dispatcher is not opposed to the running of such train for reasons connected with the general traffic situation of the line; when the dispatcher is not empowered to give orders with regard to the shunting of trains or changes in the order of running, such operations are never carried out until his opinion has been obtained; in many cases, indeed, he takes the initiative in advising such operations.

It should be noted specially that on certain railways, and on the Belgian State Railways in particular, the dispatcher may authorise goods trains to run in advance of their timetable when the service which they have to perform permits. It is thus possible to free the line of trains which, in the absence of such a possibility, would needlessly obstruct the line.

Apart from actual train movements, the dispatcher may take a part in the distribution of rolling stock, acting either as a transmission agent between the distributing offices and stations, or as a distributing agent. He may superintend the load and make-up of trains; transmit the official time; institute immediate telephonic inquiries in cases of accident or breakdown; control operations in shunting yards; compare train movement diagrams with train journals, and control the service of engines and train staffs.

Dispatchers in charge of adjoining sections must collaborate in regard to everything which jointly affects such sections; for this purpose dispatchers of a single centre are generally located in neighbouring premises; the dispatchers of different centres are in direct telephonic communication with each other.

In addition to the dispatching organisations which control a section, there are, on certain railways, dispatching organisations of a lower degree known as « regulating centres », which control the whole of train movements inside a station.

We find, further, on the Belgian State Railways, a dispatching organisation of higher degree which controls the railways as a whole; being in direct contact with all the sectional dispatching offices, this higher organisation is kept informed of any occurrences which may affect the train service, movements in marshalling or exchange yards, the situation as regards wagons awaiting dispatch, transport movements proposed, etc.

The « central dispatching » settles all difficulties of a general nature which cannot be dealt with by the sectional dispatchers; and it is further in a position, in view of its knowledge of the traffic situation of the whole railway,

to plan out in advance the special or auxiliary trains necessary at various periods of the year.

The central dispatching office also keeps in touch with the central Motive Power Department to ensure that engines are distributed over the railway system in accordance with the general needs of the service.

Wherever the dispatching system has been adopted it has resulted in a considerable improvement in the traffic service, as it makes it possible, in particular, to take advantage of any gaps revealed by the train diagrams, these gaps being visible at a glance to the dispatcher whereas they are not readily ascertained by stations.

It has thus been possible to effect an appreciable increase in the commercial speed of goods trains, with a corresponding saving in working expenses. It has thus been possible in many cases to increase the capacity of a railway while deferring, or in some cases avoiding altogether, the necessity for incurring expenditure on extensions.

On single lines the action of the dispatcher is particularly effective by reason of the facilities which he possesses for making the most suitable arrangements, according to the circumstances, for the passing or overtaking of trains throughout the whole of his section in case of train delays.

In the different countries in which the dispatching system has been introduced the saving effected more than compensates for the establishment charges and working expenses of the new organisation.

IV. — SUMMARY.

1. — The « dispatching system » or « control system » consists in directing (or supervising, correcting without delay any mistakes which have been committed) certain traffic operations on a section, by means of a special organisation which is in rapid telephonic or telegraphic communication with shunting yards, stations, traffic posts and engine depots of the section.

The main object of the « dispatching system » is to speed up the movement of traffic so as to obtain the maximum possible output from each line.

In this sense the dispatching organisation may be required to deal with all or part of the following : supervision of the running of trains, particularly with a view to ensuring strict observance of the timetable; the giving of orders (or in the case of certain railways, advice) to stations, with regard to the fixing or changing of shunting points on double lines, and of passing or overtaking points on single lines; maintenance of a reasonable ration between the number of trains run and the traffic to be handled, by the ordering of auxiliary trains where necessary and by cancelling certain scheduled trains on days when they can be dispensed with; the loading of trains up to their maximum capacity; selection of the type of engine for each train according to the nature of the work to be performed; changing the route of trains, or cancelling trains, in case of bad weather, accidents, or fouling of the line; supervision of make-up of trains to obtain complete trains for the longest distances possible with the least possible number of stops; regulation of traffic in the direction of terminal stations and ports of embarkation; measures for dealing with traffic which does not form part of the regular traffic service; utilisation of engines other than those engaged in scheduled services.

The dispatching organisation may also extend its activities to cover the following : distribution of rolling stock, the ordering of drivers, firemen and train staffs and control of their working con-

ditions; the drawing up of running tables and diagrams; notification of official railway time; control of operations in shunting yards.

2. — Dispatching centres may work independently, subject however to co-ordination with neighbouring centres as regards matters of common interest.

They may also be grouped under the control of higher dispatching organisations (Belgian State, where the whole of the dispatching units of the railway system are controlled by the Central Administration through a special organisation known as the « central dispatching »; United States, where on many railways the dispatchers of a given division are responsible to a chief dispatcher attached to the staff of the Superintendent; Great Britain, where on certain railways there are, in addition to the local control centres, both divisional and central control organisations.

3. — Rapid communication between the dispatcher and the posts with which he works in the controlled area is effected either by the Morse telegraph or by telephone, generally with a system of conventional calls based on the Morse alphabet.

In a number of cases use is made of the selector telephone, which appears particularly well adapted to the needs of dispatching work.

In most cases the dispatcher receives, from the posts with which he is in contact, notification of delays which exceed a certain limit, or of times of departure, arrival or passing of trains. He records this information on appropriate forms or registers, or on a map, or in certain cases on a diagram showing the actual running of all trains, this diagram being constantly added to as each notification is received.

On lines where the density of traffic is sufficient to warrant it, this latter method appears the most satisfactory, as it gives the dispatcher, at any moment, a complete view of the exact situation regarding every train on his section.

The same result is obtained on the British railways by means of boards on which cards corresponding to the various trains move according to the situation of the trains on the line.

4. — Special mention may be made of the dispatching system in operation on the secondary railways of Czechoslovakia, where its adoption has made it possible to dispense with service superintendents at stations, the only officials concerned with train movements being the dispatcher and the head guards.

5. — The power possessed by the dispatcher on certain railways to authorise goods trains to run in advance of their timetable when circumstances permit, seems calculated to increase considerably the output of a line.

6. — The experience of the British railways seems to show that the economic results of dispatching are susceptible of considerable improvement when the engine service (current maintenance and utilisation for hauling trains, excluding of course large repairs and construction) is under the same control as the traffic service.

7. — Wherever it has been adopted, the dispatching system has made possible an increase in the commercial speed of goods trains and an increased line output, making it possible to defer or dispense with certain work on extensions.

On railways where the dispatcher controls the loading of trains it has been found that there is an increase in the tonnage carried per train-kilometre and a decrease in the engine journeys per effective ton-kilometre.

In all cases the expenses entailed by the adoption of the dispatching system are more than compensated for by the economies resulting from its application.

QUESTION VIII

(Suburban services),

By E. C. COX and ARTHUR R. COOPER, special reporters.

Question VIII has been dealt with in the following reports :

No. 1 [1] by ourselves, dealing with America and the British Empire;

No. 2 [2] by Mr. Direz, Assistant Traffic Manager of the French State Railways, concerning all other Countries.

These reports are based on data received in response to two different questionnaires, but a general similarity obtains in regard to the information sought.

Report No. 1 is divided into two parts, the first dealing mainly with the suburban services of trunk lines, and the second with the sub-surface railways of London.

Report No. 2 relates almost exclusively to the lines serving Paris, including sub-surface railways; and the author mentions that in the territory under review, Paris is the only City where more than 4 000 or 5 000 suburban passengers per track per hour have to be carried, involving the making of special arrangements for their transport.

The subject matter of both reports can be conveniently divided under the following heads :

I. — Stations : terminal and intermediate;
II. — Track : lay-out and equipment;
III. — Rolling stock;
IV. — Operation;
V. — Fares;
VI. — General.

I. — Stations : Terminal and intermediate.

1° *Terminal.* — The situation of terminal stations in large Cities is invariably such that the adjoining land is exceedingly valuable, and enlarging such stations can, therefore, be undertaken only when all other means of increasing their capacity prove to be inadequate. For the same reason, loops or siding lines projected beyond the terminal, for reversing and stabling trains, are generally possible only on sub-surface railways. Other available methods of increasing terminal capacity are :

a) The arrangement of the running lines so that a group of these serves a particular group of platforms, enabling conflicting movements to be reduced to a minimum and thus securing better use of the platform tracks.

(A general provision where maximum use of platform tracks is required is to have four of these to every pair of running tracks.)

b) Where locomotives are in use, the provision of a separate engine dock for, and facing, each platform road, access to and egress from which can be obtained without interfering with trains passing on any other road; or, where this is impracticable, the scheduling of all engine movements which foul the running lines.

(In report No. 2 the use is advocated of an intermediate line between two

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(1) See *Bulletin of the International Railway Congress Association*, January 1925, p. 31.

(2) See *Bulletin of the International Railway Congress Association*, March 1925, p. 583.

platform tracks mainly for the movement of locomotives, but the arrangement outlined above seems to be in more general use, probably on account of the valuable space required for intermediate lines.)

c) Where steam locomotives are used, the provision of water cranes near the buffer stops, so that sufficient water may be obtained for the next outwards trip while passengers are detraining and entraining; and of coaling facilities at outlying terminals, thereby saving time and avoiding the necessity at the inner terminal for engines to be shunted across running lines to and from the Locomotive Depot or coal stage.

2° *Intermediate.* — For intermediate stations, island platforms are preferred, on account of the staff economy which can be effected.

It is very desirable that the height of station platforms should approach as nearly as possible to the level of the car floor, with a view to expediting the loading and unloading of passengers.

Where it is required to reverse a part of a service and one terminating train can be despatched before the arrival of the next, the provision of a middle platform road is most advantageous, and facilitates the interchange of passengers.

The positions of platform entrances and exits at the several stations on a route should be so arranged as to aim at equally distributing the passengers throughout the length of the trains.

II. — Track : Lay-out and equipement.

Where the running lines were unable to accommodate the number of trains it was desired to run, the following methods of increasing the track capacity have been adopted :

a) The adoption of flying and burrowing junctions to avoid tracks crossing on the level;

b) The reduction in length of block signalling sections to the minimum consistent with safety, which in some instances involved fixing speed limits for trains not fitted with the continuous brake, as well as for trains which are so fitted but which are booked not to stop at certain intermediate stations;

c) The installation of track-circuiting, accompanied in many cases by automatic signalling; and repeating signals where the view is somewhat obstructed or an early indication is desired.

III. — Rolling stock.

The carrying capacity of a railway depends upon the number of trains which can be handled on the running tracks and at the terminals (which matters are discussed above), and the number of passengers that can be accommodated per train.

The methods adopted to increase the train accommodation include the following :

a) The use of two-storied vehicles, with or without roofing. Such vehicles can be employed only in exceptional cases where sufficient top clearance is available. This type of vehicle appears to be in vogue only on the French State and Eastern Railways in Paris. The former railway no longer builds this class of coach, but the latter has recently put in hand the construction of a large number provided with roofs covering the upper deck. It is stated that more than 1 400 passengers can be carried in a train of these cars 650 feet long and weighing less than 300 tons. These vehicles are unpopular with the passengers on account of the limited height of each story, and the process of loading and unloading passengers at stations is said to be slow;

b) Increasing the length of trains. This is limited in many cases by the platform accommodation and the tractive power available. Moreover, it is found

that when the exits at the central terminal are at one end of the platforms, a tendency is noticeable for passengers to crows towards that end of the train; and, if trains are unduly long, the vehicles at the opposite end to the exits are generally only partially filled;

c) Reducing the floor space per passenger, by decreasing the size of the seats and the space between rows of seats; and or by reducing the number of seats, thereby freeing space in which passengers can stand. Each of these methods interferes with the comfort of passengers, and is therefore open to objection. It is stated that in recent years the proportion of standing passengers has been considerably increased on the Paris subsurface railways, but the suburban system of the French State Railways has now been compelled to undertake to provide seats for all passengers except those travelling within a radius of 3 miles round Paris.

With regard to the general design of suburban carriages, two distinct types of vehicle are found :

1° Saloon or open cars;

2° Cars divided into a number of compartments.

The former contains a passageway through the middle or on one or both sides of the car, and entrance is gained by two or more doors of suitable width placed at convenient intervals along each side. The latter type is provided with a smaller door on each side of each compartment.

Report No. 2 states that new electric vehicles for services round Paris are fitted with large sliding doors and a central passage. These doors are closed automatically by one of the train staff, who, by operating a plunger, controls the six doors on one side of the two vehicles which form a section.

Opinion is divided as to the best design of coach for general suburban work.

It is noted in Report No. 2 that no example has been found in the countries concerned of conversion of former steam traction stock to electric motor vehicles. This has been and is being done to a considerable extent in England by the Southern Railway.

IV. — Operation.

A large quantity of valuable plant and numerous staff have to be provided to cope with the peak hour load. It is therefore desirable to encourage travel in the intermediate hours, in order to make the fullest possible use of this provision. Two means of attaining this end are mentioned in the Reports :

1° The running of a frequent train service;

2° The institution of cheap fares.

Where the service is very frequent during the peak hours, some reduction in the number of trains can be made for the intermediate period; and considerable economy can be effected (particularly with multiple unit electric stock) by reducing the number of vehicles in the trains.

It is reported that the railways serving Paris are called on to handle a heavy traffic consisting of passengers engaged in the City who lunch at their suburban residences. For the convenience of these passengers a service of frequent fast trains has had to be instituted at midday. This traffic does not appear to obtain, except to a very limited extent, in the countries covered by Report No. 1.

Economy can be effected in working the traffic during the peak hours where the service is frequent, by arranging for trains to call only at alternate stations, or some similar regular sequence. This also has the effect of increasing the overall speed of trains and reducing the amount of stock and staff required, but the service at stations at which alternate trains do not call is necessarily halved. This method of working seems to be em-

ployed principally by the sub-surface railways.

The maximum number of suburban passengers has to be carried between the central terminal and a point only a few miles therefrom, beyond which each mile shows a considerable reduction. In order to satisfactorily, and at the same time economically, convey the traffic, it is therefore desirable that intermediate train reversing points should be arranged at sufficiently frequent intervals, to permit of the train service being reduced somewhat proportionately to the number of passengers to be conveyed; but this principle must not be followed to the extent of rendering too infrequent a service to the outlying districts. When such a system of working is adopted, it may be possible, particularly during the rush hours, to give the longer distance passengers the benefit of fast travel, by running their trains non-stop between the central terminal and an intermediate reversing point and calling at all stations beyond. This compels passengers journeying between certain intermediate stations to change trains, but as a rule such passengers are comparatively few in number, and their convenience can be subordinated. Report No. 2 mentions that the French State Railway has definitely reached the conclusion, both for financial reasons and in the interest of the general public, that the principle of zone stops, such as outlined above, shall be generally adopted when the suburban lines are electrified.

Reference occurs in Report No. 1 to the closing of minor stations near the central terminal. In addition to economy resulting, great benefit arises from the elimination of unprofitable short journey travel, thereby allowing improvement of other suburban services.

Generally speaking through trains are provided between the central terminal and the various branches of the suburban system; but on branches where traffic is light, some use is made of shuttle trains feeding other services at a junction. Instances occur of trains from the central terminal being divided at junctions to serve different branches, but in the reverse direction it appears to be unusual to combine branch trains at junctions to form a single train.

V. — Fares.

Suburban travel is characterised by the low rate charged per mile for ordinary fares, the average being much less than that for main line long distance journeys.

In Report No. 2 it is stated that in France the workmen's fares per kilometre are only about one-tenth of the ordinary main line third class fares, no increase in the former having been permitted. The suburban fares were originally fixed at a low rate to encourage traffic, which traffic has grown from a profit to a burden, owing to the special facilities required to handle it.

So far as report No. 1 is concerned little actual data is available, and the practice of charging for workmen's fares varies considerably. In and around London the workmen's fares are generally less than one half the ordinary suburban fares, and one third the ordinary main line fares. Weekly workmen's tickets, as well as daily tickets, are issued by some of the English Companies.

Reference has already been made to the encouragement of travel in the interval between the rush hours, and in report No. 1 it is stated that during such times return tickets are issued at single fare.

Season or commutation tickets are in use on most railways. Great diversity exists with regard to the rates charged for such tickets, these varying in England between about 30 % and 70 % of the rates per mile for ordinary suburban tickets.

Workmen's tickets are not issued in America, India or South Africa.

VI. — General.

Both reports refer to the many advantages to be obtained by using electric power for the operation of suburban services. Higher average speed and quicker clearance of sections can be obtained by this means, in addition to which the working is improved by the absence of smoke and steam. The multiple unit system for electric trains eliminates terminal shunting, and enables the length of trains to be more easily adapted to the traffic needs.

Reduction in the length of station stop can be secured by the adoption of a standard formation of trains, the superior class vehicles always being found at approximately the same spot; the provision of suitable name boards at stations, well illuminated at night; and the adequate lighting of platforms.

Increased attention is being given to the adequate indication to the public of the stations served by each train, this indication being given both at stations and, where possible, on the exterior of the train. Two types of train indicators at stations are illustrated in Report No. 1, one for terminal stations being placed on the platform, just inside the barrier, shewing the starting time of the next train and the stations served; the other type, principally for intermediate stations on the sub-surface lines, being placed in a central position on the platform and showing the respective destinations of the next three trains. The latter type is supplemented by indicators on the train, fixed adjacent to the doors, showing the destination and the names of the stations at which it will *not* call.

A special booking arrangement is installed on the Underground Railways of London, whereby all passengers entering certain stations pass through turnstiles under the control of the Booking Clerk, who, except at the busiest stations, can also collect tickets during the quieter hours. It is claimed that this arrangement effects economy in staff, and is an improvement from the point of view of passengers' convenience.

SUMMARY.

The following suggestions, based on the two reports, are proposed :

1. — To allow frequent services to be increased and ensure regularity of train running, a minute study of all details of equipment and organisation is essential.

(This comprises co-ordination of time schedules and track facilities, so as to ensure that the minimum headway is worked to on the busiest sections, by employing such methods as parallel working at junctions and timing of engine movements at terminals.)

2. — Capacity of terminals in many cases can be appreciably increased without extensive reconstruction.

(The means to this end referred to in the reports include the allocation of a group of platforms to a pair of running tracks, and the provision of separate engine bays for and facing each platform track.)

3. — The space at central terminals can be utilised to the fullest extent by arranging each platform between a pair of platform tracks.

4. — Reversing trains at a terminal can best be effected by the employment of a loop, facilities being included for withdrawing defective stock, loops, however, can be provided only in exceptional cases, on account of the cost involved.

5. — Interchange facilities at terminals in large cities should receive special consideration; as, where the suburban travel involves long distance journeys, a change for final distribution cannot generally be avoided, the charac-

teristics of the respective services being different.

6. — Electrification must include the provision of multiple unit stock, or its equivalent, for efficient terminal working.

7. — To minimise the length of station stop, the height of platforms should approach as nearly as possible to the level of the car floor.

8. — To economise staff, island platforms are to be preferred at intermediate stations.

9. — Maximum track capacity is afforded by the use of modern signalling methods; automatic signalling, with track circuits, permitting the use of block sections of the minimum length.

(Where freight or express passenger trains have to run on lines so signalled, certain restrictions may have to be imposed for such trains.)

10. — Carriages of suburban trains should have a large carrying capacity per unit of length, and should be provided with numerous doors, or doors of large size.

11. — Compartment stock is preferred where the journey is to the outer suburban area, on account of its high seating capacity. Saloon (open) stock is customary for short journey distribution work, where stations are only about half a mile apart, and the provision of seats for all passengers is less important.

12. — Economy and speed can be secured in rush hours when trains are frequent, by a system of zoned stops, so that train loads are concentrated for distribution to as few points as possible; but a reasonably frequent service should be provided at all stations.

(Such practice will enable portions of the service to be reversed at suitable intermediate points, which must be provided with satisfactory reversing facilities such as an intermediate platform road.)

13. — The most satisfactory and economical service during slack hours, is provided by trains of reduced length, run at uniform intervals and calling as a rule at all stations.

14. — It is desirable that railways should be empowered to close certain minor stations near the central terminal where the receipt are small and the provision of a service onerous.

QUESTION IX

(Fixed signals).

The report will be published ultimately.

SECTION IV. — GENERAL.

QUESTION X

(The eight-hour day).

The report will be published ultimately.

[313 385 .(01)]

QUESTION XI

(Statistics),

By A. E. KIRKUS, special reporter.

Question XI, which relates to « Development of railway statistics with the special view of economy in operation » has been dealt with in two reports. Report No. 1 (1) by the writer of this summary refers to the progress made in all Countries except the United States of America and South America; Report No. 2 (2) by Colonel J. T. Loree deals with the development on American Railways.

Report No. 1 is divided into four parts, *viz.:* 1) an introductory note; 2) an account of the statistics compiled and the changes made in individual countries; 3) general remarks, and 4) conclusions. Appendices have been added giving particulars of the statistics compiled by railway undertakings in a few selected countries so that the members of the Congress may be in a position to make comparisons with their own statistics.

The space devoted in the Report to individual countries has been determined chiefly by the changes made since 1900, and by the amount of information which has been furnished by the respective administrations, or which I have been able to obtain from various documents.

The evidence shows that there has been a considerable development of railway statistics during the past twenty-five years. The increase in the size of the various systems owing to amalgamations and new construction, the growth in traffic, the rise in costs and the need for economies wherever possible, together with the increasing complexity of railway business, have emphasised the necessity for adequate statistics. Consequently, more attention is now devoted to the compilation of information shewing the results of operation, and the effect of changes in policy. The general tendency has been to extend the use of statistics to all branches of railway operation, and to subject the working results to a much more detailed analysis and examination than was formerly the practice. In several countries the matter has been investigated by committees ap-

(1) (2) See *Bulletin of the International Railway Congress*, November 1924, p. 947 and May 1925 (1st part), p. 1465.

pointed to consider how the utility of the data compiled could be increased.

It would appear that the countries in which the most important developments have taken place are Australia, Canada, China, Great Britain and India. In New South Wales the whole system of operating statistics was remodelled in 1919 as a result of the investigations made by a Committee which was appointed by the administration. In Canada drastic changes were made in 1906, and the schedules prescribed by the Interstate Commerce Commission of America were adopted; further alterations were made in 1915 in order to maintain comparable particulars with those compiled in the United States. In China the statistics prepared on the State Railways were entirely revised and brought into conformity with the statistics of other countries as from the 1 January, 1915. In Great Britain the principal developments occurred in 1913 and 1920 consequent upon the passing of the Railway Companies (Accounts and Returns) Act, 1911 and the Ministry of Transport Act, 1919. In India important changes took place in 1923, following upon the investigations made by Major F. H. Budden and Mr. W. H. Scott.

At the time when the Report was drafted, the Italian State Railways were actively engaged in revising their operating statistics with a view to their simplification, and the addition thereto of new information; the State Railways in Greece had decided to put into force a more complete system of statistics, and it was anticipated that additional statistics would be required on the Belgian State Railways to give effect to the proposal that the railways should be dealt with on the basis of an industrial undertaking.

Since the Report was issued I have received a further communication from the Swiss Federal Railways in which it is stated that the information which they compile has been extended considerably since the beginning of 1924. Statistics relating to passenger, goods, and live stock traffic are now ascertained in greater detail, and the information is summarised to show particulars for the various descriptions of traffic at each distance *viz.* : 1 km., 2 km., 3 km., etc. Actual ton-kilometres of freight traffic (based on chargeable distances) are compiled for every month in the year instead of being estimated from results ascertained for certain months only. Train-mileage is compiled not only for sections of line, but also in each direction, and the statements show :

a) Number of trains;
b) Number of train-kilometres;
c) Number of axles, subdivided into :

Passenger carriage axles,
Luggage-van and mail-van axles,
Freight wagon axles (Swiss),
Freight wagon axles (Foreign);

d) Number of axle-kilometres;
e) Number of gross tons;
f) Number of gross ton-kilometres.

Under each of the above headings passenger trains are distinguished from freight trains, and regular trains from optional and special trains.

As a result of the developments in recent years there is now little difference in the fundamental or basic figures which are compiled on the principal railway systems in Asia, Europe, and in the British Dominions and Colonies, for the use of those responsible for, or interested in, the general administration and policy of the railways. The basic figures which are compiled by most undertakings include train and engine-miles, train and engine hours, vehicle-miles, net ton-miles, passenger-miles, particulars of locomotives, carriages and wagons owned, available for use, and in use, fuel consumption, etc. In some countries it is the practice to compile also gross ton-miles and axle-kilometres.

Differences exist in the segregation of the figures, and in the methods of compilation. Some of the variations in segregation are due to the different methods of charging for conveyance. Certain countries give more detailed information than others in regard to rolling stock owned, *e. g.*, locomotives are sub-divided in classes and figures of horse power or tractive effort are shewn. Differences in the methods of compilation go far to impair the value of international comparisons. In this connection mention may be made of the fact that in some countries net ton-miles are calculated on the distance the traffic is conveyed, while in other countries they are based on the distance charged for; in New South Wales the receipts per ton-mile exclude terminals, in other countries they include terminals; in Great Britain a ton consists of 2 240 lb. whereas in some countries it comprises only 2 000 lb.

Basic figures, if used separately, are of limited value only. The general tendency now is to develop and make use of what may be termed « derivative » statistics (*i. e.*, a combination of two or more basic figures) to a greater extent than was formerly the practice. These include :

Engine-miles, and engine-hours in traffic, per day per engine in use;

Train-miles per train hour and per engine-hour;

Wagon-miles per train-hour, per shunting-hour, and per engine-hour;

Ton-miles per train-hour, per shunting-hour, and per engine-hour;

Ton-miles per route-mile;

Average distances of freight and passenger traffic;

Average receipt per ton and per passenger;

Average receipt per ton-mile and per passenger-mile;

Number of vehicles per train;

Average load per vehicle;

Average load per train;

Per cent of loaded wagon-miles to total wagon-miles;

Lb. of coal consumed per engine-mile;

Pints of lubricating oil used per 100 engine-miles.

Statistics which may be regarded as two of the final tests of economy in operation, *viz.*, cost per freight ton-mile and cost per passenger-mile, are rarely ascertained because of the difficulty of allocating the total expenditure of a railway between goods and passenger traffic. For the sake of uniformity and convenience the Canadian National Railways follow the rules prescribed by the Interstate Commerce Commission of the United States. In a few other countries the division is made on arbitrary bases. In Belgium passenger and freight expenses were divided before the war on the basis of engine and train-kilometres, and the administration are at present seeking another method of separation calculated to give a more exact result. The Committee appointed to examine Indian railway statistics, to which I have previously referred, found in the course of their enquiries that « it was the general opinion of all Agents that they would welcome some more scientific methods of dividing the expenditure between passenger and goods working », and the Committee recommended that the matter should be examined with this object in view.

The importance of domestic (or internal) statistics, as distinct from the figures which are published, should not be overlooked. Domestic statistics are essential to local officers in their efforts to secure efficiency and economy in the working of the area under their control. They enable the chief administration to see the results of the efforts of local officers, and when the average results for the whole system shew a decline, they should enable the locality where the working is not satisfactory to be discovered readily.

I am not in possession of complete particulars of the domestic statistics in all countries, but I have been able to obtain sufficient information to shew that they differ widely in form and scope in different countries. Where the railways are privately owned the domestic statistics vary considerably on the individual undertakings in the same country.

A few examples of the statistics which do not appear to be compiled universally, or, in the countries named, are subdivided in a special manner, may be of interest.

In New South Wales, train and engine miles, and ton and vehicle miles, are taken out on a sectional basis for traffic in the up and down directions separately; a complete analysis of locomotive enginemen's time is made, and every minute of the driver's time from signing on to signing off is accounted for under different headings.

Considerable attention is given in most countries to the quantities of fuel and oil consumed. In Belgium the statistics compiled under this heading enable Headquarters to group the figures for locomotives of any one type, or for all locomotives attached to any one shed. By this method it can be determined whether certain services have shewn excessive consumption, and in the case of a particular shed a comparison can be made of the fuel consumed by each type of engine. It is stated that if the consumption at a particular shed is increasing, it is a simple matter to pick out the engine types which have had a preponderating effect on the fuel consumed. Engine depots are classified in order of merit according to the percentage of economy, or excess, in fuel and oil consumption, based on a standard allowance, and the issue of statements shewing comparative results for all depots is found to stimulate the efforts of the staff to secure economies. In New South Wales ton-mileage is recorded for each class of engine (saturated and superheated separately) in order to measure coal consumption.

Statistics compiled in Canada include: Locomotive-miles equated to a common basis for the purpose of watching locomotive maintenance costs, etc.; statistics of terminal performance at principal termini; potential ton-miles, which are compiled to compare the actual average gross train load with the estimated potential load; and statistics of the number of days occupied by freight cars per average round trip, subdivided to shew how the time is spent.

In Denmark, Sweden, and Switzerland, the number of passengers, and the tons and ton-kilometres of freight traffic are shewn at each distance or in distance groups. Similar particulars are compiled by the Paris-Lyons-Mediterranean Railway of France in respect of « Petite Vitesse » traffic. In Great Britain and Ireland it is the practice each month to compile these details for a few of the principal traffics conveyed by freight trains and the programme for the whole of the principal traffics is spread over a period of two or three years.

The Paris-Lyons-Mediterranean Railway compile staff statistics on a more elaborate scale than is the general custom.

Some of the variations in domestic statistics may be due to the existence of different conditions. Other variations may be immaterial if the statements which are prepared achieve the same result. But in whatever form domestic statistics are compiled it is essential that one cardinal principle should be observed, *viz.*; that the figures should be compiled generally in a manner which, when the results for the whole system are unsatisfactory, enables the cause and the locality in which bad working is occurring to be ascertained easily. For this reason it seems desirable that the statistics in use should be built up from one uniform and well defined set of basic figures which can be manipulated to meet

the needs of officers both locally and at headquarters.

In most countries all the principal statistics are now compiled and issued monthly, instead of the bulk of the information being available only quarterly or annually. Among the countries which in recent years have adopted the practice of issuing monthly statistics regularly are — Belgium, Denmark, Great Britain, India, Italy, Norway and Sweden.

It is now a common practice to subdivide the figures into districts. In New South Wales and on the North Western Railway of India, train-miles, ton-miles, and vehicle-miles are taken out on a sectional basis for traffic in the up and down directions separately. On the Swiss Federal Railways certain statistics are compiled in a similar manner. On the Paris-Lyons-Mediterranean Railway in France, train and engine-kilometres, vehicle-kilometres, gross and effective ton-kilometres and average loads (gross and effective) of freight trains and waggons, are compiled for each line forming the system.

More attention has been given in recent years to the preparation of clear and definite instructions for the guidance of those responsible for the compilation of statistics, and greater accuracy and uniformity have been secured thereby.

The use of calculating machines has resulted not only in greater accuracy and rapidity in compiling statistics, but also in reductions in the number of staff engaged on this work.

In some countries the issue of the monthly figures to executive officers has been further expedited by despatching the statements relative to each phase of working immediately these particulars become available, instead of waiting until the whole of the statistics for the month are ready.

A significant feature of recent years, and one which indicates the increased importance attached to statistics, has been the appointment of Statistical Officers with separate staffs. Appointments of this kind have been made on the State railways in Canada, New South Wales, and Western Australia, and on the railways in Great Britain all of which are privately owned. Major Budden and Mr. Scott, in their report to the Railway Board of India, also recommended that a special statistical officer should be appointed on each of the Indian Railways. I think it is true to say that where a statistical officer has been added to the organisation the effect has been to eliminate overlapping in the compilation of statistical data, to secure greater accuracy and uniformity, and to enable better use to be made of the information available.

One factor which I believe at one time prevented full and effective use being made of the statistics available, was that they were not properly appreciated by the staffs generally. Every one will agree that it is essential that the methods of compilation, and the use which can be made of the various figures separately and collectively, should be widely known. It is generally recognised that the increasing complexity of railway business necessitates in a greater measure than ever before systematic study on the part of members of the staff, and the subject of statistics is prominent in the courses of instruction, which in recent years the railway companies in Great Britain have provided through the universities and by classes arranged at convenient centres.

In Report No. 2 Col. Loree states that the statistics prepared by American Railroads at the present time are compiled for one of two purposes, *viz.:*

1° Production of economy, or
2° Historical data,

and that they are generally expressed in terms of :

a) Physical units, or
b) Monetary units.

The reporter has dealt almost exclusively with that class of statistics whose purpose is defined as production of economy, neglecting historical data designed for special public use (such as reports to the Interstate Commerce Commission, State Commissions, Annual Reports, etc.), except where the statistics are compiled originally with the object of securing economy.

It is stated that there are certain elements which are the essence of value in statistics. The figures must be made available promptly; if comparative, they must be truly so, not only in the units used in their preparation, but in the methods of their collection, preparation and exposition; they must be prepared in such a way as to inform the recipient of conditions modifying usual standards, yet not exaggerating any form or enshrouding any necessary detail. Useful statistics must paint a complete picture of the subject upon which they are to enlighten the mind, and the judgment of which they are to aid.

For many years after the opening of railroads in America, the managerial personnel grew up on the properties, which were not so large but that to those men, every detail was well known. Today the ramifications are so numerous and the demands upon the time of the managerial forces so great, and in a large number of cases on subjects more general than particular to their own department or properties that the compilation and use of statistics has of recent years received a tremendous impetus. So much so, that a large proportion of the staff in the Accounting Department on some railroads, and of entire special departments of others, now devote their time exclusively to this work, which ranges from the most minute and detailed statistical analysis for the divisional and lower departmental officers to broad comprehensive statements for the chief executives.

Economy of operation is defined by Col. Loree as rendition of adequate service to the public at the highest financial return to the owners of the properties. Therefore he considers that every statement prepared must, in the broadest sense, have this aim in view; in other words, must bear on the handling of a passenger or ton of freight, at the least cost per mile of transportation, this unit being inclusive of terminal and all other charges. The whole of the statistics, both regular and special, prepared by each department, have this object in view, just as each department in its particular field aids in producing the passenger-mile or ton-mile. It is stated that these departmental statistics serve, not only as a gauge of the work of the individual department, but when assembled and co-related one to the other, they present to the executive a comprehensive picture of the performance of the railroad as a whole.

Col. Loree then proceeds to give detailed particulars of the statistics compiled by the following departments :

Maintenance of way and structures;
Motive power;
Car;
Fuel;
Stores;
Traffic;
Transportation;
Signal;
Personnel;
Safety;
Loss and damage claim.

In conclusion the reporter states :

« Such progress has been made in the « compilation and exposition of statis« tics that it would appear that every « phase of construction, maintenance, « and operation, is now set forth in « basic figures.

« It is in the original compilation, « promptitude, and form of presentation, « that future progress lies.

« All basic figures for comparative « purposes, not only upon an individual

« system but upon every system, must « be collected in exactly the same way « and even in some cases, at the same « time; therefore, the necessity of close, « concise and emphatic instructions.

« As the officer receiving the statis- « tical matter is further removed from « the detail, so must the exposition in « routine reports present a more com- « prehensive and broader picture.

« In the selection of form, the use of « figures or graphs is a matter of indi- « vidual taste. It is true, however, that « in many cases, when figures are used, « too much detail is presented with a « resultant loss of perspective. On the « other hand, lack of care in the selec- « tion of the form of graph to an even « greater extent misstates the facts.

« Routine reports should express facts « only, never conclusions.

« In connection with recommendations « for construction, standard material, or « practice changes, statistics may be « used to strengthen the argument but « they are rarely in themselves con- « clusive.

« The choice of the terms, *i. e.* Phy- « sical Units or Monetary Units, is, it « would appear, almost totally depend- « ent upon the purpose of the particular « study.

« So long as the compensation of offi- « cers and other employees takes the « form of monetary compensation, just « so long will performance expressed in « monetary units make the greater im- « pression.

« There are many reports, however, « especially when comparisons are made « over periods longer than a year, which « better represent the conditions by the « use of Physical Units.

« This condition arises from the rapid « and violent fluctuation caused by the « inflation and deflation of the monetary « unit of the country, which makes com- « parisons based upon such unit unin- « structive.

« Such physical units are, however, « affected by the same causes that affect « the value of the monetary unit, and « are subject as well to changes in cli- « matic and weather conditions.

« As the object of the statistics report- « ed upon is economy in operation, the « prompt computation is essential and « while statistics compiled at a date long « after the operation may be satisfactory « for public bodies or as a historical re- « cord, they are valueless to operating « officers.

« It is felt that a resume of reports, « shewing nature, units used, forms em- « ployed and date to be rendered might « be useful, representing a composite « picture of American Operating Statis- « tics. »

(These are printed as Appendices to the Report.)

QUESTION XII

(Joint Stations and Lines),

By R. COPE, Special reporter.

The present note sums up the four reports received.

Report No. 1, by Mr. Collot and Mr. Bruneau (France) (1);

Report No. 2, by Mr. U. Lamalle (all countries except America, the British Empire, France, China and Japan) (2).

Report No. 3, by Mr. R. Cope (America, Great Britain, Northern Ireland, India, Dominions, Protectorates and Colonies) (3).

Report No. 4, by Mr. J. Murai (China and Japan) (4).

It will be observed that the reports cover the railways in all countries where joint working arrangements operate and it appears that in every instance the Company or Administration using the Lines, Stations and Conveniences of another Company or Joint undertaking pays for such services proportionate to the user; such payment is made either by a division of the expenses incurred or by allocating to the Company performing the services a proportion of the receipts accruing to the user Company. The information recorded by my Co-reporters and myself, already published, fully details the various services coming within the joint arrangements and the following is a summary of the methods of arriving at a basis for division of joint expenses :

Joint stations.

1° Number of trains using the stations;

2° Number of cars and engines of trains using the stations;

3° Amount of receipts from the sale of tickets;

4° Number of tickets sold;

5° Number of passengers using the station;

6° A combination of either of the foregoing;

7° Weight or tonnage of goods, or :

a) Office expenses, including salaries of the agent and clerical forces, are divided on an item basis — the items usually consisting of the number of waybills handled for each line;

b) Wages of freight handlers and checkers and other freight station expenses, such as interest, maintenance, taxes, insurance and all operating costs (heat, light, water, etc.), are divided on the basis of the number of tons of freight handled for each line through the joint station;

c) Interest, maintenance and taxes on team tracks and the cost of switching cars to and from the same as well as of switching to and from the joint station, are divided on the number of loaded cars handled for each line. The above methods are also used at joint freight transfers, except that the wages of the office forces are usually divided on the tonnage basis also.

Joint lines. — Joint line working expenses, including maintenance, rates, signalling, and staffing of the joint line, are apportioned between the owning interests in agreed proportions, a half and half basis is one most commonly adopted. In the case of tenant Companies the owning Company is credited with the whole of the receipts from the point of junction and an allowance is made to the Company working the traffic, gener-

(1) (3) (4) See *Bulletin of the International Railway Congress Association*, January 1925, pp. 119, 139, 140, 150, 151. 178.

(2) See *Bulletin of the International Railway Congress Association*, February 1925, p. 571.

ally a percentage of the gross receipts. In some cases however, a flat rate per mile is charged. Where this arrangement is varied, the cost of operating a « trackage section » is divided on what is described as a wheelage basis.

Joint junctions. — Joint junction working expenses are borne either wholly by the incoming Company, or if signalling or interlocking arrangements previously existed at the point of junction, the expenses are divided according to the services rendered for each interest. The basis of this division is invariably upon the number of levers required for controlling the lines and connections of each Company (levers operating jointly for two interests are apportioned equally). It is reported that the number of trains passing is occasionally adopted as a unit for the division of expenditure. Where the lines of two separate Companies converge into a jointly owned line, the signalling expenses are borne by the joint line account and divided proportionately between the interested Companies.

The working expenses at exchange points, or interchange tracks, are generally apportioned equally between the interested Companies.

Lines worked by a system other than the owning Company. — This group may be divided in two parts :

1° A line constructed by one Company and leased to another or others jointly and operated by the lessees.

In this case the lessee Company usually operates the line, as a part of its own system, retaining all the revenue and paying all expenditure in connection with operating and maintaining guaranteeing the lessor the interest on debentures or bonds outstanding and the dividends on the other stock of the lessors.

When the leased line is operated jointly by one or more Companies, the same principles apply and the expenses incurred on joint account are paid, in the first instance, by one or other of the operating Companies and shared proportionately between the lessee Companies.

Where there is no separate capital issue, the receipts accrue to the Company owning the line and operating Companies are allowed fixed rates per train mile or a percentage of the receipts to cover working expenses.

2° An intermediate section of one Company's line worked by a tenant Company where the traffic of the section is not of a sufficient volume to admit of an economical working by both Companies and it is arranged that the tenant Company's trains shall carry the traffic of the section.

In this case the owning Company retains the whole of the receipts and a fixed allowance is made to the tenant Company either at a flat rate per passenger or ton; or a percentage of the receipts for working the traffic.

Town Offices. — Where a joint arrangement exists at a Town Office, the expenses are usually apportioned between the parties interested on the basis of units of work performed for each Company; the number of passengers booked, the number of parcels or postal packets dealt with, and in the case of merchandise, the amount of goods handled for each interest.

Accidents. — As a general practice the expenditure in connection with accidents is excluded from the general settlement of the joint line or station expenses and is the subject of a special arrangement between the parties interested in the joint stations or sections of joint lines.

It has not been found possible to agree a general standard arrangement, but the following appears to be the usual method adopted :

a) Accidents to workmen : The amount of the compensation paid is in the first instance dealt with by the employing Company or Committee and is

ultimately apportioned in the same manner as the wages of the employee at the time the accident occurred.

b) Accidents to passengers in trains : The Company which has been credited with the revenue derived from the passenger booking is considered to be liable whether the mishap is caused through neglect of its own servants or the servants of the administrating Company. In the case of a passenger whose journey is local to a joint line or section of a joint line, the joint committee would be responsible for any loss or claim paid.

c) Other accidents : In other respects whether the damage be rolling stock or permanent way, buildings, etc., the cost is borne by apportioning to the party or parties whose servants or works have contributed to the mishap.

Fire. — Cases are reported where each Company insures its own property and also its share in the joint property but where by agreement between the interested parties, the joint property is separately insured the premiums payable are included in the joint accounts.

* * *

In conclusion, I may say that the general practice is for the accounts for joint expenditure to be prepared periodically and apportioned on a basis previously agreed. The units forming the basis of division, whether passengers, trains or tonnage, etc., are specially recorded for each period either yearly or half-yearly.

It has, however, been found possible in some cases to agree a commuted annual payment to cover all services rendered for the user Company at a particular Station, and in the case of a joint line or a line used by a tenant Company, a similar payment to cover the user of a section of line. In other instances, to obviate the necessity of specially recording a selected unit for the basis of the division of the joint expenses, the user of a particular Company is investigated for a certain period and the result whether based on the number of passengers, tonnage of goods or the unit of work, *e. g.*, numbers of waybills issued, is resolved into a fixed proportion which is adopted for the division of the expenses, subject to review periodically if circumstances appear to demand a revision.

These commutations effect a considerable economy in connection with recording of information, but detailed accounts are more favoured as they reflect currently all changes in items of expenditure or user.

It will be noticed from the reports that although the principles governing the division of joint expenses are, on broad lines, the same in every country, yet owing to variation due to certain local factors, it has not been found possible to standardise either the agreements or the method of apportioning the expenses, and, as the circumstances vary at almost every place, the method of apportionment adopted is the one which has been found, upon investigation, to be the most equitable.

The basis of a joint arrangement is to insure that the expenditure is equitably apportioned and where the value of the work for one interest cannot be fairly determined by a division on the basis of numbers of passengers or tonnages alone, the numbers of trains or goods vehicles are frequently introduced. As each settlement is dealt with on the merits of the particular case, it is not possible to say that any method of apportionment has an advantage over the others. On the other hand, these variations have been accepted by all parties concerned as being fair and equitable.

SECTION V. — LIGHT RAILWAYS AND COLONIAL RAILWAYS.

[625 .61]

QUESTION XIII

(Establishment of light railways),

By H. MARRIOTT, special reporter.

Two reports are presented on this question, *viz.* :

1) by Mr. Bonneau and 2) by Mr. H. Marriott (1). Unfortunaly Mr. Tsang Ou, who had intended to deal with China and Japan, has been unable to complete his report.

Mr. Bonneau's report deals with all countries except America, the British Empire, China and Japan. The replies to his questionnaire were interesting but many administrations or affiliated companies stated that they did not run light railways. The railways in question appear to have been constructed on permanent lines and have undergone little change. The metre gauge has been generally adopted except on the Dutch Indian Railways where the gauge is 1 m. 067 (3 ft. 6 in.). The author raises the point as to whether this is measured between rail centres, in which case it would be equivalent to metre gauge.

The weight of rails varies from 20 to 26 kgr. (40.3 to 52.4 lb. per yard) but replacements of heavier section are being made where less than 25 kgr. in certain cases.

Metal sleepers are used almost exclusively on the railways in French colonies, whereas those in use in other colonies of similar districts are of wood.

Rolling Stock generally consists of light locomotives and goods wagons of 10 tons capacity except in Java where Mallet compounds of 60 tons are used, similar to those running on the main line.

The author suggests that it may be considered worth while at future sessions of the Congress to reserve a special title for railways laid down to open up new countries without classifying them with those usually called « light railways ».

Mr. Marriott, reporting on America and the British Empire, states that so far as the United States are concerned the term « light railway » is seldom if ever applied there, and that in Canada there is nothing analogous to the light railway as generally understood.

In the British Isles the mileage of light railways is about 1 500, with fourteen gauges ranging from 14 inches to 4 ft. 8 1/2 in. The 3 ft. gauge is the most favoured with a mileage of 638. The practice in New South Wales (Australia) up to the year 1890 has been to construct all lines up to the standard (4 ft. 8 1/2 in.) gauge. Since that time, in order to minimise the capital cost, a considerable portion of the mileage has been constructed of the light pioneer type with 60 lb. per yard rails and the

(1) See *Bulletin of the International Railway Congress Association*, number for October 1924, pp. 847 and 873.

permanent way laid on earth formation and ballasted with earth.

In India there are about 15 000 route miles of metre gauge and about 3 000 miles of 2 ft. 6 in. gauge lines. The latter are constructed in a substantial manner, carrying large rolling stock on a permanent way of usually 41 lb. per yard, flat bottomed rails laid on wooden sleepers and ballasted with broken stones, at an average cost of construction (pre-war prices) of about £ 1 000 per mile.

Jamaica has a railway mileage of 200, of 4 ft. 8 1/2 in. gauge. The view is expressed that a gauge of 3 ft. 6 in. or metre gauge would, in addition to being cheaper, have better suited the mountainous nature of the island.

In South Africa there are about 1 135 miles of narrow gauge lines of which 437 miles are in the South West.

The author then states that the subject of light railways has been under discussion at previous meetings, and points out that as there appears to be some doubt as to the meaning of the term — what is regarded as a light railway in one country may be the recognised standard line in another — a clear definition seems desirable. Dealing now with the position of Great Britain the author describes the working of the Light Railways Act of 1896 and refers to the relatively small development which has taken place. He quotes figures showing that only 936 miles have been constructed although authority had been given by the Tribunal for 2 235 miles, and that up to 31 December 1923, less than half of the Treasury Fund of one million sterling had been assigned towards light railway development. The author then proceeds to discuss the reasons for this disappointing state of things and draws attention to the voluminous report of the Light Railways Investigation Committee appointed in March 1920, « to examine and report upon the future policy and development of light railway operation and construction in the United Kingdom ». This Committee examined the subject in all its bearings and their findings are in the opinion of the author of great value. Among other important recommendations they state that « where a proposed light railway is to be so located that no connection with the main line is possible or likely to be required the choice of gauge may be determined in the main by considerations of economy in construction and maintenance. They further recommend « that where connection is to be made with a main line or there is reason to think that such connection may ultimately be necessary, a narrow gauge should not as a rule be adopted unless the proposed light railway is to have a lead of more than 20 miles or is intended to form an integral part of an existing narrow gauge system which could not advantageously be converted to standard gauge, and that in cases where it is decided to depart from the standard the gauge selected should be 2 ft. 6 in., which should in future be regarded as the standard dimension for narrow gauge lines ».

The author then expresses the opinion that in the development of new countries and districts where the traffic prospects are not sufficient to justify the capital cost of a standard gauge line a 2 ft. 6 in. gauge might be laid cheaply in such a manner and on the understanding that it can be easily lifted if and when a standard gauge line is justified in the general interest.

The report proceeds to discuss the question of weights of rails prescribed by Light Railway orders and quotes the view of the Investigation Committee that the considerations which should guide the Government Departments in deciding whether any particular line should or should not be treated as a light railway under the Act of 1896 are intimately associated with factors of speed, permanent way construction, and weight of rolling stock.

They suggest that *maximum speeds* might be found to constitute one of the most important governing factors and

that light railways should be classified in two groups as under :

1) Lines having an authorised maximum speed of 25 miles per hour, and
2) Lines having an authorised maximum speed of 15 miles per hour.

The author then proceeds to refer to the development achieved in countries where there is almost an entire absence of restrictions and describes at length the Decauville system on the Argentine.

He then describes the « Road rail » system with illustration which is already being tried in opening up new districts and which combines the principles of road and rail transport and the « Rutway » system which the inventor claims can on ordinary ground such as the plains of India be laid down, if of 20 miles or more in length, for about £ 1 000 per mile complete with rolling stock.

The special reporter has endeavoured to condense the main points in the two reports comprising 26 pages and draws special attention to the following :

1) The suggestion that in one of the future Sessions of the Congress it may be found worth while to reserve a special title for railways laid down to open up new countries without classifying them with those usually called « light railways »;

2) The desirability of a clear definition of a light railway;

3) The desirability of a modified form of light railway construction on the lines recommended by the Light Railway Investigation Committee, as compared with that which has hitherto been considered necessary in some countries with the view of opening out new districts at cheap cost and affording favourable means of transport;

4) The examination and trial of some of the new methods described in the Reports and results reported at next meeting of the Congress.

[625 .611]

QUESTION XIV

(Concessions for light railways), [1]

By PIERRE LO BALBO, special reporter.

The question of the economic and financial status of secondary railways has been dealt with at previous sessions from various special points of view.

At the Washington Congress in 1905, in particular, the question as worded was in some respects similar to that with which we are now dealing, and was dealt with in a very able manner by Messrs. Colson and Ziffer.

Since that time it may be said that the concessions for light railways have received a great deal of attention from various governments. This fact may be explained for two reasons. In the first place the very large amount of capital absorbed by developing a system renders its financial status an extremely important matter. On the other hand, by reason of the nature of things and the requirements of public safety, the transport business is of necessity a monopoly, so that we cannot rely upon the effect of competition to correct abuse or deficiencies which may exist; at the same time this service exercises a very great influence on the development of all kinds of agricultural, industrial and commercial enterprises, so that its organisation and rates are a matter of general interest of the very greatest importance, in which public authorities cannot but be concerned. For this reason, the legislation and rules for railways and tramways nearly always present exceptional difficulties and are extremely complicated.

At the 1900 session, the methods of developing light railways were discussed, and at this Congress attention was drawn to the necessity of financial assistance from the State or districts concerned and by the existing railways.

For the London session in 1925, the question is worded : « Relations between the concessionnaires of light railways and the authorities granting the concession. Economic and financial administration. »

A questionnaire has been sent out to the various Administrations belonging to the Association, and we will take this opportunity of thanking those Administrations which have kindly assisted the reporters in their task.

In accordance with the information received, the reporters, Mr. Biraghi and myself, agree in stating that it is very difficult to lay down any general rules as regards this question, because the arrangements adopted in different countries vary in accordance with the special conditions in each country.

However, the report forms an interesting record from the point of view of the arrangements made by the conceding powers in certain countries during and after the war of 1914-1918, with the object of allowing the light railways to continue in face of the very great difficulties in which they found themselves.

The great interest taken in these lines is an indisputable proof of the importance and considerable influence which secondary railways have in improving the economic and social conditions of the various countries.

It is very true that the tendency of

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[1] Translated from the French.

present day legislation in a number of countries is to offer more liberal terms to light railways. However, one should allow the concessionnaires to be as free as possible from any restrictions in operating the lines. Providing that safe working is assured and that the rights of the public and of the conceding powers are respected, liberty should be given to the concerns working the lines to organise the service as they think best and to fix the rates on what they consider a practical basis.

From the consideration of the points emphasised by the two reporters, we propose the following final summary :

I. — For the construction and operation of light railways, financial aid on the part of the conceding powers is necessary.

II. — The conditions of construction and operation should be such as will allow the interests of the concessionnaires to harmonise with the requirements of the public. As a general rule it is necessary that the conceding powers should allow the greatest amount of flexibility and freedom so that it may be possible to carry out the construction economically and ensure simple, economical, commercially sound and rational operation.

III. — Except in cases where an equitable arrangement has been arrived at, the new lines should not be burdened with free or semi-free services, the cost of which should be borne by the conceding powers, since they would have continued to pay for these if the new lines had not been constructed.

IV. — The principle of the participation of the State in the gross receipts of light railways being irrational from the point of view of operation, and opposed to the public interest, should no longer form a clause in the legal agreements.

[625 .616]

QUESTION XV

(Traction on light railways), [1]

By Mr. DE CROËS, special reporter.

Two reports have been drawn up on this question.

The first deals with the British Empire and America [2].

The second deals with countries other than the above [3].

The English reporter points out that in England and America there are few lines whose characteristics are identical with those of light railways on the Continent of Europe. This consideration has led him to divide his report as follows :

A. — Traction by combustion engines on railways in general.

B. — Systems of traction on narrow gauge railways.

C. — Roadrail System.

In order to meet traffic requirements on the majority of English branch lines, trains drawn by light tank engines are more suitable than rail motor-coaches.

One finds therefore only a small number of the latter, and almost all are worked by steam. From the table published as an appendix it will be seen that the four main English railway companies possess only 7 petrol engines as compared with 96 steam engines of this type. The Great Western Railway, in the case of certain suburban services, uses steam motor-coach trains consisting of a locomotive in the centre with two carriages in front and two behind. As these trains can be driven from either end, the time spent in terminal stations is reduced.

The present tendency in England is to develop road motor transport, and to abandon the construction of light railways.

Traffic conditions on a large number of American lines have led to a greater development in America than in England of the use of petrol motor-coaches.

After having in the first place experimented with heavy types, railway companies now prefer light types designed on the lines of the motor car.

The most favoured type is one which will carry about 35 passengers and 900 kgr. (1 985 lb.) of luggage. Vehicles of this type weigh about 10 tons; they have a leading bogie and a rear motor axle.

The maximum speed is about 50 km. (31 miles) an hour, and the petrol consumption is from 40 to 50 litres per 100 km. (14.08 to 17.60 Imperial gallons per 100 miles).

From the table prepared in respect of two American companies, it appears that working expenses are considerably lower in the case of petrol motor-coaches than in the case of steam engines.

Turning to the Colonial railways the reporter refers to the development of the

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(1) Translated from the French.

(2) See *Bulletin of the International Railway Congress Association*, November 1924, p. 1007.

(3) See *Bulletin of the International Railway Congress Association*, April, 1925, p. 993.

use of petrol motor-coaches on the railways of New South Wales. On these railways 636 km. (395 miles) are served by seven rail motor-coaches. Their weight varies from 7 950 to 26 800 kgr. (17 525 to 59 085 lb.), and they range from 50 to 160 H. P. Further extensions are contemplated; the Administration is considering the possibility of using heavy oil motors for future motor-coaches.

A table annexed to the report gives details of the rail motor-coaches referred to above, and also of those in use on the railways of Southern India, Rhodesia, Barbadoes and Kalka Simla.

The steam motor-coaches used in Jersey are also referred to.

Reference is also made to the advantage which might result from the use of combustion engine locomotives for the less important sections of goods traffic, and to the advantage of the adoption of electro-pneumatic control, which would allow of combining several motor-coaches in one train.

Passing to the second chapter, dealing with the methods of traction on narrow gauge railways, the reporter refers in the first place to Colonial lines which have adopted steam traction.

The Bengal Nagpur Railway Company, with 1 012 km. (629 miles) of line (760 mm. [2 ft. 6 in.] gauge), has a monthly traffic of 215 000 passengers and more than 60 000 tons of goods. Powerful steam locomotives are in use which can haul trains weighing up to 500 tons. A table annexed to the report gives more detailed information with regard to this railway, and to other railways of 1 m. or 600 mm. (3 ft. 3 3/8 in. or 2 feet) gauge worked by steam traction.

During the war the reporter was in charge of British military transport on the Western Front, on the lines between the main railways and the front line positions. The light railways laid down for this service were of 600 mm. (2 feet) gauge, with rails weighing on an average 9.92 kgr. per metre (20 lb. per yard). They carried up to as much as 200 000 tons of traffic per week.

Use was made of :

1) Steam locomotives weighing from 7 to 14 1/2 tons;

2) Petrol electric locomotives, 40 to 45 H. P., weighing 8 tons;

3) Petrol tractors of from 20 to 40 H. P., chiefly on the badly maintained track of the forward areas;

4) Transformed Ford chassis, for inspection and relief work.

The reporter terminates the chapter with a reference to the Buenos Aires Great Southern Railway which, for transporting goods to its main lines, has recently laid down more than 330 km. (205 miles) of 600 mm. (2 feet) gauge line. Steam locomotives are only used in the potato-growing districts. In corn-growing districts petrol tractors are preferred. With the latter there is no danger of causing fires along the line; the nature of the water available in this region is not of so much importance for these tractors as in the case of steam locomotives, and they can be driven with a smaller and less skilled personnel than is required for steam locomotives.

For privately owned lines, where simplicity of working is the first essential, the reporter notes the use of petrol tractors fitted with low speed horizontal single-cylinder motors.

To reduce the amount of work which would be involved by the adoption of easy gradients, and to make it possible to use light railways in Colonial regions where traffic is small, steep gradients are adopted even though, to give the motors a sufficient degree of adhesion, it may be necessary to resort to mechanism for gripping the rails, or to the roadrail system.

The latter system has been used for the last three years in Uganda on 45 km. (28 miles) of line. The wagons run on a 600 mm. (2 feet) gauge track, while the

driving wheels of the tractors run on the ground on either side of the rails. The up-grades are 4/100, or, in exceptional cases, 5/100. The petrol tractors are supported in front on bogies running on the rails, and the driving wheels are behind. The latter carry a total weight of 3 810 kgr. (8 400 lb.). In good weather the adhesion obtained allows of hauling 27 tons on 4/100 up-grades. The latest tractors built are run by steam. They are reversible as there is both a leading and a trailing bogie. They have a tractive power up to 2 540 kgr. (5 600 lb.).

The roadrail system is being developed in India, where it appears to give satisfaction.

The reporter concludes as follows :

Rail motor-coaches.

On the railways of Great Britain their future function seems to be to supplement steam traction.

In the other countries under consideration they have been found economical for small passenger traffic.

It would be useful to have more detailed information, from companies which use rail motor-coaches, with regard to the haulage and sorting of goods trains.

More powerful vehicles will gradually be substituted for the former light vehicles of the motor car type.

The adoption of systems by which it is possible to control from a single driver's post several motor-coaches combined in one train will enormously increase the possibility of using motor-coaches.

The hauling of goods trains by locomotives driven by combustion engines is still in the experimental stage.

Traction on narrow gauge railways.

Steam traction is the system most widely adopted.

Local conditions may make it more desirable to use petrol tractors in certain cases.

Tractors driven by horizontal single-cylinder motors are particularly suitable for private lines in view of their simplicity.

Special systems of traction.

These may be necessary in hilly country to give light tractors a sufficient degree of adhesion.

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The second Report deals with the situation in countries other than the British Empire and America.

We only refer therein to light railways, the gauge of which is 1 m. or less.

Steam traction, electric traction and combustion engine traction are successively considered.

We quote as examples of steam traction the 18 ton locomotive of the Belgian Light Railways, the 66 1/2 ton locomotive of the Lower Congo-Katanga Railway, and the 78 ton articulated locomotive of the Garratt type used on the Catalonian Railways.

A description is given of the Restucci valve, with which it is possible to reduce the running expenses of locomotives.

In the countries under consideration steam motor-coaches have not proved particularly satisfactory; their use is not very widespread.

Electric traction is used more especially in the suburban services of large towns, in industrial centres and in mountainous regions.

The advantages of electric traction are wellknown. Generally the main problem is one of finance. Progress has been made in the direction of reducing the initial cost by adopting high tensions; and working expenses have been reduced by using mercury rectifiers and automatic sub-stations.

Combustion engines are suitable for use on light railways.

Up to the present the characteristics of these engines make it necessary to provide intermediate means of transmitting power to the axles. This may consist of cog-wheel gearing, or transmission may be effected either by electric, pneumatic or hydraulic systems.

Cog-wheel gearing is used on the lighter or average weight rail motor-coaches. Its use on the heavier vehicles is only in the experimental stage.

Electric transmission is very expensive, and up to the present has been found suitable more particularly in the case of the higher powered vehicles.

Pneumatic transmission has not been very widely adopted and its practical value has still to be ascertained.

Hydraulic transmission is still in the experimental stage.

The possible use of heavy oils and, in the case of many countries, the supply of liquid fuel, are the main elements of the problem of using combustion engines on railways.

From the information available it appears reasonable to draw the following summary :

1. — That steam traction is still the system of most general utility. It does not, however, appear that, as far as light railways are concerned, there is any prospect of appreciably reducing the present high cost of this system.

2. — That the adoption of electric traction depends essentially on financial considerations. The latter differ according to the conditions prevailing on the different lines. In proportion as initial expenditure and working expenses diminish, it will be possible to develop the use of this system of traction.

3. — That the combustion engine system of traction is at present advantageous in certain cases, and that it will doubtless be used to an increasing degree on light railways.